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ESBC

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COVER: ***Chrysopa nigricornis*** **Burmeister (Neuroptera: Chrysopidae)**

This green lacewing is common across southern British Columbia and ranges as far north as the Skeena River. With its delicate green body and golden eyes, it is one of our most beautiful insects. Seven of the ten recognized species of *Chrysopa* in North America occur in Canada and all of these are recorded in British Columbia. Adults and larvae are voracious predators and play an important role in the control of aphids and many other pests.

Photograph details:

Chrysopa nigricornis, captured at Penticton, BC in June 1982 and photographed live in a glass terrarium. Nikon F2 with 55 mm macro lens, #1 extension tube and two small strobe flashes; Kodachrome 64 film. Robert A. Cannings and M. Brent Cooke, Royal BC Museum.

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DIRECTORS OF THE ENTOMOLOGICAL SOCIETY OF BRITISH COLUMBIA FOR 2009-10

Nine Heteroptera (Hemiptera) new to Canada, with additional new provincial records for three other species in Canada

G.G.E. SCUDDER[1]

ABSTRACT

Cenocorixa wileyae (Hungerford), *Labops utahensis* Slater, *Phytocoris heidemanni* Reuter, *Pinalitus rubrotinctus* Knight, *Corythucha celtidis* Osborn and Drake, *Geocoris frisoni* Barber, *Zeridoneus petersoni* Reichart, *Aethus nigritus* (F.), and *Melanaethus subglaber* (Walker) are reported as new to Canada. New provincial records are also given for three mirids, namely *Clivinema fuscum* Downes, *Pilophorus amoenus* Uhler, and *Polymerus vulneratus* (Wolff). *Labops utahensis* is also recorded new for Oregon, and *Aethus nigritus* from South Carolina.

INTRODUCTION

In a previous paper (Scudder 2008a), I added new provincial records for 52 species of Heteroptera in Canada, plus new state records for two species in the United States. I also summarized the records of Heteroptera for Canada published since the appearance of the checklist of Hemiptera of Canada and Alaska (Maw et al. 2000).

During the last two years, more species and records for Canada have been published by Henry (2008), Kerzhner and Henry (2008), Scudder (2008b), and Wheeler et al. (2008). New records for Alaska were also published by Lattin (2008a, 2008b) and Bauman and Hudson (2009).

In this paper, I add nine more species of Heteroptera to the Canadian list, and include new provincial records for three other species in Canada. Museum abbreviations used in the text are as follows:

CNC: Canadian National Collection of Insects, Agriculture and Agri-Food Canada, Ottawa, ON (R.G. Foottit)

DBUC: Department of Biological Sciences, University of Calgary, Calgary, AB (J. Swann)

RBCM: Royal British Columbia Museum, Victoria, BC (R.A. Cannings)

SMNH: Swedish Museum of Natural History, Stockholm, Sweden (G. Lindberg)

UBC: Spencer Entomological Collection, Beaty Biodiversity Museum, University of British Columbia, Vancouver, BC (K.M. Needham)

UG: Department of Environmental Biology, University of Guelph, Guelph, ON (S.A. Marshall and S. Paiero)

NEW CANADIAN RECORDS

The systematic order of families and higher taxa in this and the next section follows Maw et al. (2000).

Infraorder NEPOMORPHA

Family CORIXIDAE

Cenocorixa wileyae (Hungerford)

Originally described from Utah by Hungerford (1926), this species has also been recorded from Arizona, California, Colorado, New Mexico, Nevada, Oregon, and Washington (Hungerford 1948; Jansson 1972; Stonedahl and Lattin 1986; Polhemus et al. 1988). The male of *C. wileyae* has a characteristic sharply incised peg row on

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the pala of the fore leg, and the abdominal strigil is small and composed of four or five combs, as shown by Jansson (1972). The right paramere of the male is also illustrated by Jansson (1972), Lauck (1979), and Stonedahl and Lattin (1986). Lauck (1979) reported that *C. wileyae* is a common pond corixid that occurs across the northern part of California and through the Sierra Nevadas to southern California.

New record. BC: 1♂, Victoria, Ascot Pond, 27.iv.1980 (R.A. Cannings) [RBCM].

Infraorder CIMICOMORPHA

Family MIRIDAE

Labops utahensis Slater

Originally described from Utah by Slater (1954), this species was also reported from Colorado (Henry and Wheeler 1988). Although no localities in Colorado were reported in Polhemus (1994), the CNC has a number of specimens from Colorado as well as Utah, plus new records for Oregon (see below). *Labops utahensis* was keyed by Slater (1954) and characteristically has upright setae on the hemelytra, fuscous hind tibia, and with the first antennal segment as long as or longer than the length of the pronotum. The labium also reaches the apex of the hind coxae.

L. utahensis is now known to occur in Alberta.

New records. AB: 1♂, Univ. of Calgary Eco. Reserve, hand, 11.vi.1998 (RL/WF/MW) [DBUC]; 1♀, U. Calgary Barrier Lk. Fld. Stn., 51°09'49"N 115°02'01"W, 12.viii.2000 (K. Sanderson) [DBUC]; 1♀, U. of C. Kananaskis Fld. Stn., 51°01'49"N 115°02'01"W, 15.viii.2002 (N. Ozaro) [DBUC]; 1♀, 10.viii.2002 (C. Dobval) [DBUC]; 1♀, Kananaskis, U. of C. Field Station, 51°01'49"N 114°12'01"W, 11-12.viii.2004 (A. Chubaty) [DBUC]; 1♀ Barrier Lake Field Station, 51°01'49"N 115°02'W, meadow site, 6.viii.2005 (Mal. Pan) [DBUC]; 1♀, U. of C. Kananaskis Fld. Stn., 51°01'49"N 115°02'01"W, 6.viii.2008 (Laura Eggen) [DBUC]; 1♀, *id.* (Nicole Lavorie) [DBUC]; 1♀, *id.* (Robin McIntyre) [DBUC]; 1♀, *id.* (Matthew Menard) [DBUC]; 1♀, *id.* (Claire Pereila) [DBUC]; 1♀, *id.*, 7.viii.2008 (Laura Eggen) [DBUC]; 1♀, *id.* (Beauty Sandhu) [DBUC]; 1♀, *id.* (David Longelier) [DBUC]; 1♀, *id.*, 9.viii.2008 (April Garrett) [DBUC]; 2♀, *id.*, 10.viii.2008 (David Longelier) [CNC]; 1♀, *id.* (Sierra Love) [DBUC].

CO: 2♂ 3♀, Chaffee Co., Buena Vista, 22-23.vi.1961 (J.R. Stainer) (AMNH_PBI 00271540-42, AMNH_PBI 00285064, AMNH_PBI 00285071) [CNC]; 1♂ 1♀, Eagle Co., State Bridge, nr. Bond, 24-25.vi.1961 (J.R. Stainer) (AMNH_PBI 00285065, AMNH_PBI 00285072) [CNC]. OR: 3♂ 1♀, 5.6 mi NE rt. 26 on Ochoco Crk. Rd., Ochoco Creek, *Elymus cinereus* (Scribn. & Merr.) A. Love, 19.vii.1979 (M.D. Schwartz) (AMNH_PBI 00271543, AMNH_PBI 00285066-67, AMNH_PBI 00285073) [CNC].

Phytocoris heidemanni Reuter

Described by Reuter (1909) from New Mexico, this species is now known to be widely distributed in the western United States, with records from at least Arizona, California, Colorado, Montana, Nevada, South Dakota, Utah, and Wyoming (Henry and Wheeler 1988; Stonedahl 1988). *Phytocoris heidemanni* is a large species in the *P. fraterculus* Van Duzee complex, grayish brown, with a long first antennal segment, a strongly convex scutellum that is abruptly deflexed distally, and distinctive male genitalia as described and detailed in the key contained in Stonedahl (1988).

In the United States, the species is reported to have been collected on *Pinus albicaulis* Engelm., *P. contorta* Dougl., *P. edulis* Engelm., *P. monophylla* Torr. & Frem., and *P. ponderosa* Dougl., as well as *Picea engelmannii* Parry (Stonedahl 1988). *P. heidemanni* is now known to occur in British Columbia.

New record. BC: 1♂, Mt. Revelstoke N. Pk., 4.ix.1970 (L.A. Kelton) [CNC].

Pinalitus rubrotinctus Knight

Originally described by Knight (1968) from Arizona, *P. rubrotinctus* in the western United States is also reported from Colorado and New Mexico (Kelton 1977; Henry and Wheeler 1988; Polhemus 1994),

and is now known to occur in Canada in British Columbia.

P. rubrotinctus was keyed by Kelton (1977) and as in *P. rubricatus* (Fallén) the hemelytra are not mottled, but are uniform reddish yellow or reddish brown. However, the male claspers are distinctive, and as illustrated by Kelton (1977). According to Kelton (1977), *P. rubrotinctus* has been collected in the United States on *Pseudotsuga menziesii* (Mirb.) Franco, *Abies concolor* (Gord. & Glend.) Lindley, and *Pinus flexilis* James.

New records. BC: 2♀, Hope, 20 mi E, western hemlock, 26.vii.1957 (N. Anderson) [CNC]; 1♂, Riske Cr., Lt. trap, 3.viii.1978 (R.A. Cannings) [UBC]; 1♀, Campbell R., 23 km SW, *Abies amabilis* branch, 1.viii.1996 (MASS SW-T2-U-br2) [RBCM].

Family TINGIDAE

Corythucha celtidis Osborn & Drake

Originally described by Osborn and Drake (1916) from Ohio, this species is widely distributed in the eastern United States (Froeschner 1988). It is now known to occur in Canada in Ontario, with records from Essex Co. and Kent Co.

Corythucha celtidis was keyed by Gibson (1918) and Blatchley (1926) and has spinules on the lateral margins of the pronotum and the costal margins of the hemelytra. The pronotal hood is slightly higher than and about equal in length to the median carina, which is not prominently arched. The lateral carinae are short and dark brown bands are present across both the base and apex of the hemelytra. The apical band on the hemelytra is not solid, but has a few of the areoles quite hyaline. The species occurs on hackberry (*Celtis occidentalis* L.).

New records. ON: 2♀, Leamington, 12.ix.1961 (G.P. Brumpton) (debu 00015265, debu 00015266) [UG]; 9♂ 34♀, Point Pelee, *Celtis*, 4-5.vi.1961 (Kelton & Brumpton) [CNC]; 6♂ 5♀, Point Pelee, 28-29.vi.1961 (Kelton & Brumpton) [CNC]; 7♂ 2♀, Pt. Pelee, 11.ix.1961 (L.A. Kelton) [CNC]; 9♂ 15♀, Pt. Pelee, on *Celtis*, 23.v.1962 (Kelton & Thorpe) [CNC]; 1♂, Point Pelee Natl. Pk., 17.vii.1978 (D. Morris) (debu 00015248) [UG]; 1♂, *id.*, 28.vii.1978 (J. Cappleman) (debu 00015227) [UG]; 1♀, *id.*, 30.vii.1978 (W.A. Attwater) (debu 00015203) [UG]; 8♂ 4♀, *id.*, 31.vii.1978 (debu 00015205, debu 00015207, debu 00015209-18) [UG]; 1♀, *id.*, 31.vii.1978 (J. Cappleman) (debu 00015226) [UG]; 1♂ 4♀, *id.*, 31.vii.1978 (D. Morris) (debu 00015249-53) [UG]; 1♀, *id.*, 26.vi.1979 (D.L. Krailo) (debu 00015228) [UG]; 1♂ 1♀, *id.*, 26.vi.1979 (L. Templin) (debu 00015230-31) [UG]; 1♂, *id.*, 27.vi.1979 (D.L. Krailo) (debu 00015229) [UG]; 3♂ 4♀, *id.*, 10.vi.1980 (J.D. Cashaback) (debu 00015219-25) [UG]; 1♀, *id.*, 7.vii.1980 (S. Beierl) (debu 00015232) [UG]; 2♀, *id.*, 8.vii.1980 (S. Beierl) (debu 00015233-4) [UG]; 1♀, *id.*, 8.vii.1980 (D.L. Krailo) (debu 00015288) [UG]; 3♀, *id.*, 9.vii.1980 (S. Beierl) (debu 00015235-7) [UG]; 3♂ 4♀, *id.*, 9.vii.1980 (D.L. Krailo) (debu 00015239-45) [UG]; 7♂ 2♀, *id.*, 19.vi.1981 (D.H. Pengelly) (debu 00015254-62) [UG]; 1♂, *id.*, SE beach, 11.v.2000 (O. Lonsdale) (debu 0001422) [UG]; 7♂ 1♀, Wheatley, 4.vi.1961 (Kelton & Brumpton) [CNC]; 1♂, Wheatley Prov. Pk., deciduous forest, 19.ix.1993 (C.S. Blaney) (debu 01029649) [UG].

Infraorder PENTATOMOMORPHA

Family GEOCORIDAE

Geocoris frisoni Barber

Described originally from Illinois by Barber (1926), this species is brachypterous, pale yellow with regular and dense punctures on the corium. The vertex is granulose, and the scutellum and calli are entirely yellow. *Geocoris frisoni* is keyed and illustrated by Readio and Sweet (1982). It is widely distributed in the eastern United States, being reported from Indiana, Iowa, Kansas, Michigan, Missouri, Nebraska, Texas and Wisconsin (Readio and Sweet 1982). It is now known to occur in Canada in Ontario.

New record. ON: 1♀, Bruce Co., Inverhuron Prov. Pk., 44°18'N 81°35'W, dunes, 25.vii.2003 (M. Buck) (debu 01126425) [UG].

Family RHYPAROCHROMIDAE

Zeridoneus petersoni Reichart

This species was described from Utah by Reichart (1966), who published a photograph of a dorsal view. *Zeridoneus petersoni*, so far only reported from Utah, characteristically has the clavus a pale creamy tan and the corium has the apical half dark brown with a distinct subapical, more or less triangular, pale spot. The species is now known from Canada, with records for the Prairie Provinces.

New records. AB: 1♀, Calgary, 28.viii.1925 (G. Salt) [SMNH]; 1♀, Canmore, 25.viii.1952 (A.R. Brooks) [CNC]; 1♀, *id*., 28.viii.1952 (L.A. Konotopetz) [CNC]; 1♂, Stettler, 3.viii.1957 (A.R. & J.E. Brooks) [CNC]. MB: 4♀, Dauphin, 17.viii.1958 (A.&J. Brooks) [CNC]; 2♀, Pilot Mound, 31.vii.1958 (A.&J. Brooks) [CNC]. SK: 1♀, Canora, 6.ix.1959 (A.&J. Brooks) [CNC]; 1♀, Val Marie, 6.viii.1955 (A.R. Brooks) [CNC].

Family CYDNIDAE

Aethus nigritus (Fabricius)

This Palaearctic species was first collected in Delaware in 1977, and then in Connecticut in 1979 (Hoebeke and Wheeler 1984). It was also reported from New Jersey, New York, and Pennsylvania (Hoebeke and Wheeler 1984), and is now known from Canada, with numerous captures in Ontario.

Hoebeke and Wheeler (1984) provided key characters for the recognition of this species. These include the anterior margin of the head between the eyes with a submarginal row of long setae, and short, erect pegs; the peritreme of the scent gland channel forming apically a large, nearly circular, polished loop; and an extensive metapleural evaporatorium that occupies more than half of this sclerite, nearly reaching the base of the metapleural lamella posteriorly. Hoebeke and Wheeler (1984) also provided modifications for the keys contained in Froeschner (1960), Slater and Baranowski (1978), and McPherson (1982).

New records (in date order). ON: 1♀, Essex Co., Windsor, Ojibway Prairie, 42°15'51"N 83°04'30"W, 18-19.vi.2002 (O. Lonsdale) (debu 01114238) [UG]; 1♂, Hald.-Norfolk Reg., Manestar Tract, 6 km NNW St. Williams, 42°42'17"N 80°27'38"W, sandy field, 23.vi.2002 (M. Buck) (debu 00185485) [UG]; 1♀, Kent Co., Rondeau P.P., South Point Trail, nr. east pkng. lot, Carol. for., 42°15'42"N 81°50'49"W, YPT, 3-4.vii.2003 (Paiero & Cheung) (debu 01133133) [UG]; 1♀, Essex Co., Point Pelee Natl. Pk., The Dunes, 24.vii.2003 (S.M. Paiero) (debu 00219187) [UG]; 1♀, Essex Co., Windsor, Ojibway Prairie, 42°15'51"N 83°04'30"W, 25.vii.2003 (S.M. Paiero) (debu 00222337) [UG]; 1♀, Kent Co., Cedar Springs, Gore Rd., grasses, sweep net, 4.viii.2003 (J. Renkema) (debu 01029648) [UG]; 2♂ 1♀, Kent Co., Wheatley Prov. Pk., 7.ix.2007 (S.M. Paiero) (debu 00291146-48) [UG].

SC: 1♂, Georgetown Co., Hobcaw Barony, ~5 km E Georgetown, open field, WPT & YPT, 13-15.ix.2007 (Paiero & Bergeron) (debu 00290903) [UG].

Melanaethus subglaber (Walker)

This cydnid is recorded from Arizona, California, Nevada, New Mexico, Texas, and Utah, as well as Mexico and the Galapagos Islands (Froeschner 1960). As noted by Froeschner (1960), among the species of *Melanaethus* Uhler with the large terminal modification of the ostiolar peritreme extending almost to the lateral margin of the evaporatorium, *M. subglaber* can be recognized by its very elongate form and the fact that the transverse impression of the pronotum is distinct across the entire width of this sclerite, whereas the corium is distinctly polished.

New record. BC: 1♀, Summerland, 30.v.1932 (A.N. Gartrell); *Geotomus* sp.? *uhleri* Sign. Det. G.S. Walley 33 [CNC].

This species was previously recorded from British Columbia incorrectly as *Melanaethus uhleri* (Signoret) (Downes 1935 as *Geotomus uhleri* Signoret). The occurrence was not included in Maw et al. (2000), so this constitutes a new record.

NEW PROVINCIAL RECORDS

Infraorder CIMICOMORPHA

Family MIRIDAE

Clivinema fuscum Downes

This mirid was described by Downes (1924) from Saanich District on Vancouver Island, British Columbia, and so far has only been collected also on Vancouver Island in Victoria and at Leanchoil in Yoho National Park on the mainland. Until now it has been regarded as endemic to British Columbia. However, it is known to occur in Alberta.

Clivinema fuscum has a rather uniform brown coloration, with the pronotum convex and with the middle third of the posterior margin straight. The hemelytral membrane is more or less hyaline, with the apical third slightly infuscate.

New records. AB: 1♂, Waterton Lakes National Park, N5438280.660 E296797.567, yellow pan, unburned, unsalvaged, Rep. 3, 21.viii-28.viii.2001 (E. Kinsella) (DBUC 2001 00747) [DBUC]; 1♂, *id.*, yellow pan, Rep. 2 (DBUC 2001 00745) [CNC]; 1♂, *id.*, Malaise, Rep. 2 (DBUC 2001 00746) [DBUC]; 1♂, Blood Res. 148A, N5437127.790 E302345.233, Burned, salvaged, Rep 2, 21.viii-29.viii.2001 (E. Kinsella) (DBUC 2001 00744) [DBUC].

Pilophorus amoenus Uhler

This species is widely distributed in the eastern half of North America (Henry and Wheeler 1988; Schuh and Schwartz 1988), with records in Canada from Manitoba east to New Brunswick (Schuh and Schwartz 1988; Maw et al. 2000). The species is now known to occur in Alberta and Saskatchewan.

Pilophorus amoenus was keyed by Schuh and Schwartz (1988) and has the whole of the third and base of the fourth antennal segments white, a distinctly campanulate pronotum, and the anterior part of the corium and clavus is generally orange, smooth and devoid of setae, but the anterior and posterior transverse bands of setae on the hemelytra are complete and nearly straight. Hosts are reported to include *Pinus banksiana* Lamb., *P. clausa* Chapm., *P. rigida* Mill., *P. strobus* L., *P. sylvestris* L., *P. virginiana* Mill., *Picea abies* (L.) Karst and *Chamaecyparis* sp.

New records. AB: 1♀, Cold Lake, 4.ix.1970 (L.A. Kelton) [CNC]. SK: 1♂, Torch R., *Pinus banksiana*, 3.viii.1950 (L.A. Konotopetz) [CNC].

Polymerus vulneratus (Wolff)

This Holarctic species was first reported from North America by Schwartz et al. (1991), with records from Alaska, British Columbia, Northwest Territories, and Yukon. It is now known to occur in Alberta.

Polymerus vulneratus was keyed by Schwartz et al. (1991) and typically is rather pale with an overall green cast, and with moderately distributed appressed, silvery, sericeous setae intermixed with sparsely distributed suberect, black, simple seta. The structure of the vesica of the male genitalia is distinctive, and illustrated by Schwartz et al. (1991). Specimens in North America have been collected on Betulaceae (*Betula glandulosa* Michx.) and Fabaceae (*Hedysarum mackenzii* Richardson and *Trifolium* sp.).

New record. AB: 2♂ 2♀, Ft. Vermillion, Test J1, Plot 302, 11.vii.2002 (J. Unrh) (NIS#2003-187) [CNC].

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New distributional records for some Canadian Neuropterida (Insecta: Neuroptera, Megaloptera)

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ABSTRACT

The coniopterygids *Conwentzia pineticola* Enderlein, *Helicoconis californica* Meinander, *Semidalis angusta* (Banks) and *S. pseudouncinata* Meinander, and the myrmeleontid *Dendroleon speciosus* Banks are reported as new to Canada. *Semidalis pseudouncinata* is a new introduction for North America. Additional distribution records are given for six British Columbian neuropterid species, four of which are new provincial records.

INTRODUCTION

Over the past few years, distributional records have been assembled for the neuropterid insects in British Columbia, as part of an assessment of the overall species richness of the province (Warman & Scudder 2007; Austin *et al.* 2008; Austin and Eriksson 2009). Some of these records constitute species new to Canada and/or British Columbia, while others constitute significant new provincial records.

The following account documents these records. Abbreviations for museums in the text are as follows:

CNC: Canadian National Collection of Insects, Agriculture and Agri-Food Canada, Ottawa, ON.

PFC: Pacific Forestry Centre, Canadian Forest Service, Natural Resources Canada, Victoria, BC.

RBCM: Royal British Columbia Museum, Victoria, BC.

UBC: Spencer Entomological Collection, Beaty Biodiversity Museum, University of British Columbia, Vancouver, BC.

All specimens, unless otherwise stated, were identified by the authors: the Coniopterygidae by Meinander, the Hemerobiidae by Klimaszewski, and the Myrmeleontidae by Scudder. Specimen data cited are as on the specimen data labels, except that dates have been standardized: any elaboration of data labels is in square parenthesis, including the scientific name of host plants.

NEW RECORDS

Order NEUROPTERA

Family CONIOPTERYGIDAE

Coniopteryx canadensis Meinander

Heretofore known from Canada: Saskatchewan, USA: Wisconsin (Meinander 1972), and Alaska (Meinander 1990). It was keyed by Meinander (1972).

First BC Record. BC: 1♂, Osoyoos, Mt. Kobau, mi 3 [km 4.8] , Mt. Kobau Obs[e]rv [atory] R[oa]d, 990 m., 31.v-3.vi.1991 (D.C.A. Blades, C.W. Maier) [RBCM ENT 992-010045].

Conwentzia californica Meinander

Recorded from most of the western

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United States (Meinander 1972; Penny *et al.* 1997). The species was keyed by Meinander (1972).

Previously reported Canadian Records: BC, Spahats Creek Prov. Pk., on Hwy. 5, north of Clearwater (Meinander 1990).

New BC Records. BC: 1 specimen, Saanichton, *Thuja plicata*, 5.vi.1990 (FIDS 1990 90-1220-01) [PFC]; 1♂6♀, Vancouver, on box [(*Buxus* sp.)], 9.vii.1965 (G.G.E. Scudder) [UBC]; 1 specimen, Victoria, *S*[*equoiadendron*] *gigantium*, 11.ii.1994 (R. Duncan) [PFC].

Conwentzia pineticola Enderlein

This Palaearctic species is widely distributed in the United States, and in Canada has been reported from Manitoba, Newfoundland, Nova Scotia, and Ontario (Meinander 1972; Penny *et al.* 1997). The species was keyed in Meinander (1972).

First BC Records. BC: 1 specimen, Duncan, Cobble Hill, S[eed] O[rchard], Se [=Englemann spruce (*Picea engelmannii*)], beating, 30.vi.1994 (M. Hall) [PFC]; 2 specimens, Saanichton, Nootka S[eed] O [rchard], ex. Sx [=hybrid spruce], 14.ix.1992 (M. Hall) [PFC]; 1♂, Salmon Arm, 29.iv.1931 (Hugh B. Leech) [UBC]; 1♂, Victoria, beating branches of *Pinus sylvestris* with predator of *Pineus* sp., 17.iv.1993 (CFS 93-0029-05) [PFC]; 1 specimen, Victoria, Lost Lake S[eed] O [rchard], 10.ii.1993 em[erged] 22-24.ii.1993 (R.G. Bennett) [PFC].

Helicoconis californica Meinander

Described from California by Meinander (1972), this species was previously known only from that state (Penny *et al.* 1997); it is newly reported here from Alberta, British Columbia and Yukon. The species was keyed in Meinander (1972).

First Canadian Records. AB: 1♀, Jasper, on *Pinus contorta latifolia*, 17.vi.1942 (E. McDonald) [UBC]; BC: 2♂, Aspen Grove, 14.vi.1933 (K. Graham) [UBC]; 1♀, Chase Creek, Chase, on Englemann spruce, 2.vii.1942 (F.B. Beatty) [UBC]; YT: 1♂, Kluane N.P., Sheep Mt., 4.vi.1979 (G.G.E. Scudder) [UBC].

Semidalis angusta (Banks)

Described from California and Arizona by Banks (1906), this species has subsequently been reported from Arkansas, Montana, and Texas (Meinander 1972; Penny *et al.* 1997), as well as Mexico (Meinander 1990) and Nicaragua (Meinander 1995). It was keyed in Meinander (1972).

First Canadian Record. BC: 1♂, Quesnel, 5.vi.1947 (G.J. Spencer) [UBC].

Semidalis pseudouncinata Meinander

This Circum-Mediterranean species, described and keyed by Meinander (1972), has been recorded from Andorra, Croatia [as Yugoslavia], France, Germany, Italy, Morocco, Portugal, Spain, Switzerland, Tunisia, and the United Kingdom by Aspöck *et al.* (2001), and from Slovenia by Devetak (2002). The record from British Columbia noted below constitutes a new alien species in North America.

First North American and Canadian Record. BC: 2♂1♀, Duncan, ex. *Chamaecyparis nootkatensis*, 5.iv.1988 (CFS 88-10-02) [PFC].

Family HEMEROBIIDAE

Micromus variegatus (Fabricius)

A widespread Palaearctic species, until recently known in North America only from British Columbia (Klimaszewski and Kevan 1988, 1990), with records reported from Galiano Island. However, it is also newly reported from Quebec (Klimaszewski *et al.* 2009). Keyed by Klimaszewski and Kevan (1988), this species is now known in British Columbia from elsewhere in the Georgia Depression ecoprovince, as well as the Southern Interior.

New BC Records. BC: 2 specimens, Aldergrove, 14.v.1977 (G.G.E. Scudder) [UBC]; 2 specimens, Penticton, at light in S.E. Cannings home garden, adjacent to grassland, 9.vi.1995 (R.A. Cannings) [RBCM]; 1 specimen, Vancouver, 19.vii.1977 (J.A. Van Reenen) [UBC]; 1 specimen, Vancouver, 16.viii.1981 (G.G.E. Scudder) [UBC]; 1 specimen, Vancouver, UBC Campus, 2.ix.1997 (G.G.E. Scudder) [UBC]; 1♀ (probably this species), Victoria, Rocky Point, GC Site 1, Malaise, 11.vii.1994 (N.N. Winchester) [RBCM].

Psectra diptera (Burmeister)

A widespread Palaearctic species that

has been previously reported in Canada only from Newfoundland (Kevan and Klimaszewski 1986) and Ontario (Carpenter 1940), although it is known from many eastern states in the USA (Penny *et al.* 1997). The species was keyed by Kevan and Klimaszewski (1986).

First BC Record: BC: 1 specimen, White Lake, Okanagan Falls, Malaise, 1.vii.1990 (H. Nadel & R. Cannings). [RBCM ENT 991-829].

Sympherobius barberi (Banks)

Originally described from Arizona by Banks (1903), this species is widely distributed in the New World from approximately 43°N south to Peru, and on several remote Pacific island groups: Galápagos Islands, Revillagigedo Islands and Hawaiian Islands (Oswald 1988), and has been introduced into Bermuda (Bennett and Hughes 1959). In Canada it was recorded from Ontario by Klimaszewski and Kevan (1992), who also provide a key for identification.

New BC Record. BC: 1♂, Campbell River, Mohun Lake, 25.v.1988 (G. Hutchings) [RBCM ENT 991-11083].

Wesmaelius yukonensis Klimaszewski and Kevan

This species was described from the Yukon (Klimaszewski and Kevan 1987b), and was previously known only from that territory (Penny *et al.* 1997). The species was keyed by Klimaszewski and Kevan (1987a).

New BC Record. BC: 1♂, Riske Creek, CIFAC Base, light trap, 4.viii.1978 (R.A. Cannings). [RBCM ENT 991-15995].

Family MYRMELEONTIDAE

Dendroleon speciosus Banks

Originally described from Colorado by Banks (1905), this species has since been recorded from Arizona, California, Colorado, Idaho, Nevada, New Mexico, and Oregon (Banks 1927; Penny *et al.* 1997; Stange 2008), as well as Mexico (Oswald *et al.* 2002). The genus was keyed by Banks (1927) and species keyed by Stange (2008).

First Canadian Records: BC: 1 specimen, Duncan, 30.vii.1922 [CNC]; 1 specimen, Kamloops, 13.vii.1941 (G.J. Spencer) [UBC]; 1 specimen, Kaslo (J.W. Cockle) [CNC]; 1 specimen, Lac La Hache, 19.viii.1933 (W. Downes) [UBC]; 1 specimen, Lillooet [RBCM]; 1 specimen, Lillooet, viii-ix.1927 (A. Phair) [CNC]; 1 specimen, Lillooet, Seton L., 4.vii.1926 (J. McDunnough) [CNC]; 1 specimen, *id.*, 7.vii.1926 [CNC]; 1 specimen, Oliver, UBC Geology Camp, at light, 19.vii.1989 (S. Cannings) [UBC]; 1 specimen, Osoyoos, Haynes Ecol. Res., 'The Throne', pitfall rock/*Selaginella*, 10.vii-14.viii.1986 (S. Cannings) [UBC]; 1 specimen, Seton L., 22.vii.1933 (J. McDunnough) [CNC]; 1 specimen, *id.*, 23.vii.1933; 1 specimen, *id.*, 24.vii.1933; 1 specimen, *id.*, 11.viii.1933; 1 specimen, *id.*, 12.viii.1933 [CNC].

Order MEGALOPTERA

Sialis joppa Ross

Originally described from North Carolina by Ross (1937), this species is widely distributed in the eastern United States (Whiting 1991). Keyed by Ross (1937), *S. joppa* was recorded from Ontario by Stange (1990).

New BC Records. BC: 1♂, Cowichan Lake, 22.vi.1937 (Idyall) [UBC]; 1♂, Vernon, 14.v.1948 (D. Evans) [UBC].

Identified originally by Tarter and Watkins in 1979, and confirmed by M.F. Whiting in 2004.

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A checklist of the Neuropterid insects of British Columbia (Insecta: Megaloptera, Neuroptera and Raphidioptera) with a summary of their geographic distribution

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ABSTRACT

The Neuropterid orders in British Columbia consist of the Megaloptera, Neuroptera and Raphidioptera. Twelve families containing 89 species are represented. The distribution of these species is documented with reference to the 9 terrestrial ecoprovinces in British Columbia. Collection localities are given for species represented by 5 or fewer sites. Four species, 2 of Coniopterygidae and 2 of Hemerobiidae, are considered alien introductions.

INTRODUCTION

The first list of British Columbia (BC) neuropterid insects was published by Spencer (1942) at a time when the 3 orders in this group of insects that occur in the province (Megaloptera, Neuroptera and Raphidioptera) were considered as a single order, the Neuroptera. Most of the more recent research on these 3 taxa in BC, which include both aquatic and terrestrial species, was summarized by Cannings and Scudder (2001) and Scudder *et al.* (2001).

MATERIALS AND METHODS

The list of species here considered as occurring in BC follows the classification of Oswald and Penny (1991) and Penny *et al.* (1997), with some nomenclature changes published since. In the recent literature, Garland and Kevan (2007) have discussed the Chrysopidae, and Cannings and Cannings (2006) the Mantispidae. Recent new additions to the provincial list are documented by Meinander *et al.* (2009).

A georeferenced distributional database for the provincial species of neuropterid insects has been maintained by Scudder, and this is used as the basis for the following summaries.

We have indicated the general geographic distribution of each species by listing alphabetically the abbreviations of the ecoprovince(s) (Fig. 1) in which it has been recorded. An ecoprovince is an area with consistent climatic or oceanographic, topographic and geological history (Meidinger and Pojar 1991, Demarchi 1996). There are 10 ecoprovinces in BC; their size and broad internal uniformity make them ideal units for the general discussion of geographic distribution of organisms in the province. One of the ecoprovinces is completely marine and is omitted from this study.

In the list, collection localities are given for species known from 5 or fewer localities (39 species, 44% of total). If a species is found in two or more ecoprovinces and if one of these ecoprovinces contains more than half the collection localities for that species, that ecoprovince abbreviation is printed in bold font.

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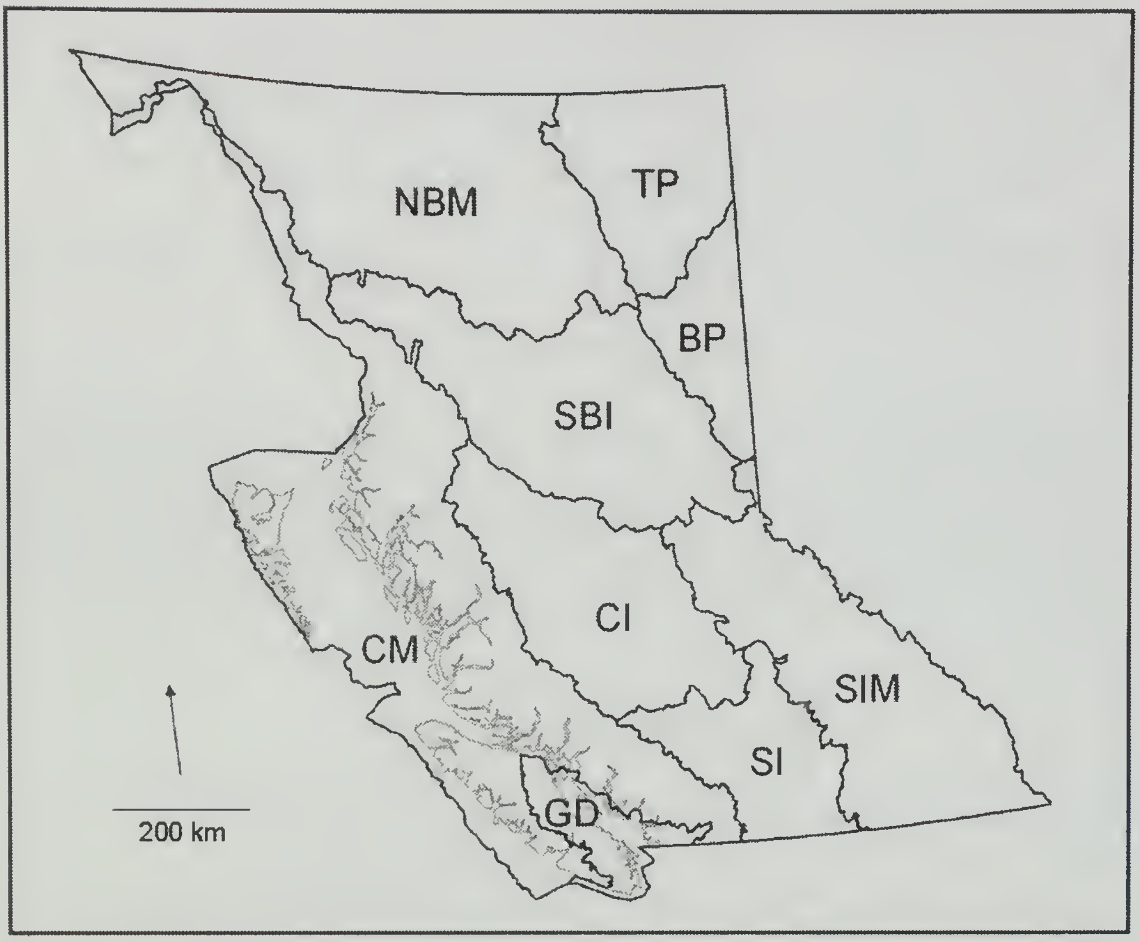

Figure 1. Map of British Columbia showing the nine terrestrial ecoprovinces: BP, Boreal Plains; CI, Central Interior; CM, Coast and Mountains; GD, Georgia Depression; NBM, Northern Boreal Mountains; SBI, Sub-boreal Interior; SI, Southern Interior; SIM, Southern Interior Mountains; TP, Taiga Plains.

RESULTS

Table 1 lists the 89 species of neuropterid insects known from BC. The Megaloptera is represented by 2 families, 4 genera and 9 known species, while the provincial totals of the more diverse Neuroptera are 8 families, 25 genera and 73 species. The Raphidioptera in BC consists of 2 families, 2 genera and 7 known species.

DISCUSSION

The georeferenced distributional database for the neuropterid species in the province has been utilized in an assessment of the overall species richness in the province (Warman and Scudder 2007; Austin *et al.* 2008; Austin and Eriksson 2009).

Two species of Coniopterygidae (*Conwentzia pineticola* Enderlein and *Semidalis pseudouncinata* Meinander) and one species of Hemerobiidae (*Psectra diptera* (Burmeister)) are considered alien Palearctic introductions to BC, while a second hemerobiid (*Micromus variegatus* (Fabricius)) may have been introduced from Japan (Klimaszewski and Kevan 1990; Penny *et al.* 1997). A fifth alien species, the coniopterygid *Conwentzia psociformis* (Curtis) was intercepted in Victoria in 1958 on a shipment of *Rhododendron* plants from Holland (Meinander 1972). In contrast to the other aliens, C. *psociformis* appears not to be established in BC and is omitted from our list.

The 3 neuropterid orders are found throughout much of BC. The majority of records of each order come from the southern half of the province, a bias that probably reflects both the greater intensity of

Table 1.
Checklist of the neuropterid species of British Columbia and their distribution in BC's eco-provinces.

Order Megaloptera (Dobsonflies and Alderflies)

Family Corydalidae (Dobsonflies)

Chauliodes pectinicornis (Linnaeus). GD. Cloverdale, Cowichan.

Dysmicohermes disjunctus (Walker). CI, CM, **GD**, SI, SIM.

Protochauliodes spenceri Munroe. GD.

Family Sialidae (Alderflies)

Sialis californica Banks. CM, **GD**, SI.

Sialis concava (Banks). Reported from BC by Whiting (1991); lacks locality data.

Sialis hamata Ross. SIM. Creston.

Sialis joppa Ross. GD, SI. Cowichan Lake, Vernon.

Sialis rotunda Banks. CI, **GD**, SI, SIM.

Sialis velata Ross. **SI**, TP. Osoyoos, Penticton, Salmon Arm, Petitot River.

Order Neuroptera (Lacewings, Mantidflies, Antlions and Relatives)

Family Berothidae (Beaded Lacewings)

Lomamyia occidentalis (Banks). SI. Penticton, Lytton, McGillivray Creek (S of Lillooet).

Family Chrysopidae (Green Lacewings)

Chrysopa chi Fitch. BP, CI, CM, GD, NBM, SI, SIM, TP.

Chrysopa coloradensis Banks. CI, GD, **SI**, SIM.

Chrysopa excepta Banks. SI. Oliver, Penticton, Nicola.

Chrysopa nigricornis Burmeister. CI, CM, GD, SI, SIM.

Chrysopa oculata Say. BP, CI, CM, GD, NBM, SBI, SI, SIM, TP.

Chrysopa pleuralis Banks. CI, **SI**, SIM.

Chrysopa quadripunctata Burmeister. GD. Vancouver Island.

Chrysoperla carnea (Stephens). BP, CI, CM, GD, NBM, SBI, SI, SIM, TP.

Dichochrysa perfecta (Banks). SI. Oliver, Penticton, Summerland.

Eremochrysa canadensis (Banks). SI. Penticton.

Eremochrysa fraterna (Banks). SI.

Eremochrysa punctinervis (MacLachlan). SI.

Meleoma dolicharthra (Navas). CM, GD, SI, SIM.

Meleoma emuncta (Fitch). CI, CM, GD, SI, SIM.

Meleoma schwarzi (Banks). SI. Penticton.

Meleoma signoretti Fitch. CI, CM, **GD**, SIM.

Nineta gravida (Banks). GD.

Nothochrysa californica Banks. CM, **GD**.

Family Coniopterygidae (Dustywings)

Coniopteryx canadenisis Meinander. SI. Mount Kobau.

Coniopteryx tineiformis Curtis. CI, SI. Quesnel, Cache Creek.

Conwentzia californica Meinander. **GD**, SI. Saanichton, Victoria, Vancouver, Spahats Creek Park (Clearwater River Valley).

Table 1. (continued)

Family Coniopterygidae (Dustywings) (continued)

Conwentzia pineticola Enderlein. Introduced. **GD**, SI. Duncan, Saanichton, Victoria, Salmon Arm.

Helicoconis californica Meinander. SI. Aspen Grove, Chase.

Helicoconis similis Meinander. SIM. Moyie Mountain.

Semidalis angusta (Banks). CI. Quesnel.

Semidalis pseudouncinata Meinander. Introduced. GD. Duncan.

Family Hemerobiidae (Brown Lacewings)

Hemerobius bistrigatus Currie. CM, **GD**, SIM.

Hemerobius conjunctus Fitch. CI, CM, GD, NBM, SI, SIM.

Hemerobius costalis Carpenter. CM, CI, NBM, SI, TP.

Hemerobius discretus Navás. CI, CM, **GD**, NBM, SI, SIM.

Hemerobius dorsatus Banks. BP, CI, CM, GD, NBM, SI.

Hemerobius humulinus Linnaeus. CM, GD, NBM, SI, SIM.

Hemerobius kokaneeanus Currie. CI, CM, GD, NBM, SI, SIM.

Hemerobius nigrans Carpenter. CI, GD, NBM, **SI**, SIM.

Hemerobius ovalis Carpenter. CI, CM, GD, NBM, SI, SIM, TP.

Hemerobius pacificus Banks. BP, CM, **GD**, SI, SIM, TP.

Hemerobius pinidumus Fitch. BP, GD, NBM, SI, SIM.

Hemerobius simulans Walker. NBM, **SI**, SIM. Telegraph Creek, Tujony Lake, Salmon Arm, Vernon, Trinity Valley.

Hemerobius stigma Stephens. CI, CM, GD, NBM, **SI**. SIM.

Megalomus angulatus Carpenter. GD, SI. Galiano Island, Lillooet.

Megalomus fidelis (Banks). BP. Rolla.

Micromus angulatus (Stephens). BP, CI, CM, GD, NBM, SI, TP.

Micromus borealis Klimaszewski & Kevan. CI, CM, NBM, SI, SIM.

Micromus montanus Hagen. CI, CM, GD, SI, SIM.

Micromus posticus (Walker). BP. Pink Mountain.

Micromus subanticus (Walker). **GD**, SI. Galiano Island, Vancouver, Penticton.

Micromus variegatus (Fabricius). Probably introduced from Japan. **GD**, SI. Aldergrove, Vancouver, Galiano Island, Rocky Point (Victoria), Penticton.

Micromus variolosus Hagen. CI, GD, **SI**.

Psectra diptera (Burmeister). Introduced. SI. White Lake (Okanagan Falls).

Sympherobius angustus (Banks). CI, SI. Chilcotin, 100 Mile House, Penticton, West Bench (Penticton).

Sympherobius barberi (Banks). GD. Mohun Lake (Campbell River).

Sympherobius californicus Banks. SI. Oliver.

Sympherobius killingtoni Carpenter. SI. Osoyoos, Penticton, Vernon.

Sympherobius perparvus (MacLachlan). CI, **SI**. Riske Creek, Keremeos, Merritt, Vernon.

Wesmaelius brunneus (Banks). NBM, SI, SIM. Coal River (Alaska Highway), Silver Star Mt. (Vernon), Mt. Revelstoke.

Wesmaelius coloradensis (Banks). CI, GD, NBM, **SI**.

Table 1. (continued)

Family Hemerobiidae (Brown Lacewings) (continued)

Wesmaelius furcatus (Banks). NBM. Summit Lake (Alaska Highway), Toad River (Alaska Highway), Pleasant Camp, Atlin.

Wesmaelius involutus (Carpenter). CI, CM, GD, NBM, SI, SIM, TP.

Wesmaelius longifrons (Walker). CI, CM, GD, NBM, SI, SIM.

Wesmaelius nervosus (Fabricius). CM, GD, NBM, SI, SIM.

Wesmaelius pretiosus (Banks). SI. Nicola, Oliver, Oliver Geology Camp, Penticton.

Wesmaelius yukonensis Klimaszewski & Kevan. CI. Riske Creek.

Family Mantispidae (Mantidflies)

Climaciella brunnea (Say). GD, **SI**, SIM.

Leptomantispa pulchella (Banks). SI.

Family Myrmeleontidae (Antlions)

Brachynemurus abdominalis (Say). CI, CM, **SI**, SIM.

Brachynemurus ferox (Walker). CI, **SI**.

Brachynemurus peregrinus (Hagen). SI. Lytton, Oliver, Osoyoos Lake N end.

Dendroleon speciosum Banks. CI, GD, **SI**, SIM.

Myrmeleon exitialis Walker. CI, CM, GD, SI, SIM.

Family Polystoechotidae (Giant Lacewings)

Polystoechotes punctata (Fabricius). CI, CM, GD, SBI, SI, SIM.

Family Sisyridae (Spongillaflies)

Sisyra fuscatus (Fabricius). GD, SI, SIM.

Sisyra vicarius (Walker). GD, SI, SIM. Agassiz, Cultus Lake, Lillooet, Oliver, Kaslo.

Order Raphidioptera (Snakeflies)

Family Inocellidae

Negha inflata (Hagen). **SI**, SIM.

Family Raphidiidae

Agulla adnixa (Hagen). CI, CM, GD, SI, SIM.

Agulla assimilis (Albarda). CI, CM, GD, SI, SIM.

Agulla bicolor (Albarda). SI.

Agulla crotchi (Banks). SI. Summerland.

Agulla herbsti (Esben-Petersen). GD, **SI**.

Agulla unicolor Carpenter. CM, **SI**, SM.

collections and the higher diversity of species in the South. This trend is more obvious in the Megaloptera and Raphidioptera than in the Neuroptera. Table 2 shows that the latter order is distributed in all ecoprovinces; the Raphidioptera is not recorded in the 4 most northerly ecoprovinces and the Megaloptera is found in only 1 of these 4 (a single record of *Sialis velata* in the Taiga Plains). All but 6 of the 84 localities (some localities have multiple records) of Megaloptera are from south of 51°N and all but 12 are from coastal environments. Although 2 of the 6 species of *Sialis* are known only from east of the Coast Mountains, the other megalopteran species are mostly coastal. All records of *Chauliodes pectinicornis* and *Protochauliodes spenceri* are coastal as are 40 of 44 localities for *Dysmicohermes disjunctus*. The Raphidioptera is the most strongly southern of the orders; the most northerly records are of

Table 2.
Occurrence of neuropterid orders in the ecoprovinces of British Columbia.

Code	Ecoprovince Name	Raphidoptera	Megaloptera	Neuroptera
NBM	Northern Boreal Mountains			X
TP	Taiga Plains		X	X
BP	Boreal Plains			X
SBI	Sub-boreal Interior			X
CM	Coast and Mountains	X	X	X
GD	Georgia Depression	X	X	X
CI	Central Interior	X	X	X
SI	Southern Interior	X	X	X
SIM	Southern Interior Mountains	X	X	X

Agulla adnixa from Quesnel and Tete Jeune Cache, both approximately 53°N. However, all but 5 localities are from the warm southern valleys and coastal areas south of about 51°N.

Our analysis herein shows that the two regions most threatened by habitat modification, Southern Vancouver Island/ Fraser Valley and the Okanagan Valley also support the most diverse faunas of neuropterid insects (Austin *et al.* 2008). Five species are known only from the former region – *Chauliodes pectinicornis* and *Protochauliodes spenceri* (Corydalidae), *Nineta gravida* and *Nothochrysa californica* (Chrysopidae) and the introduced *Semidalis pseudouncinata* (Coniopterygidae). The Okanagan Valley has 10 species not recorded elsewhere – *Dichochrysa perfecta*, *Eremochrysa canadensis* and *Meleoma schwarzi* (Chrysopidae), *Coniopteryx canadensis* (Coniopterygidae), *Psectra diptera* (introduced), *Sympherobius californicus* and *S. killingtoni* (Hemerobiidae), *Leptomantispa pulchella* (Mantispidae), *Agulla bicolor* and *A. crotchi* (Raphidiidae).

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Haliplus leechi Wallis and *H. salmo* Wallis: a new synonymy and sexual dimorphism in the relative eye separation (Coleoptera: Haliplidae)

REX D. KENNER[1]

ABSTRACT

Examination of the holotypes, specimens in the type series and material from across their geographical ranges for *Haliplus leechi* Wallis and *H. salmo* Wallis shows that the two names are conspecific; *H. salmo* is placed as a junior subjective synonym of *H. leechi*. A sexual dimorphism in the relative eye separation is present in members of this complex, *H. canadensis* Wallis and *H. subguttatus* Roberts. Preliminary data suggest that this dimorphism may also be present in other haliplid species. This dimorphism should be taken into account in constructing keys for the determination of haliplids.

INTRODUCTION

Haliplus leechi Wallis and *H. salmo* Wallis are very similar structurally. *Haliplus leechi* is a widespread (Vondel 2005) species described from material collected in Stanley Park, Vancouver, BC. *Haliplus salmo* was described from specimens recovered from the stomach of a trout caught in Jasper, AB and has a more restricted distribution (Vondel 2005). Wallis (1933), in his description of these species, admitted that "it is possible that one is but a geographical race of the other". However, he felt that these two taxa could be separated based on differences in background color, maculation, punctulation and relative eye separation. The results of an investigation of the taxonomic status of *H. leechi* and *H. salmo* are reported here.

Relative eye separation, the dorsal distance between the eyes divided by the headwidth, is a character frequently used in keys for the determination of haliplids (Wallis 1933; Holmen 1987; Vondel 1991, 1993, 1995; Vondel and Spangler 2008). In his revision of the Nearctic species of *Haliplus* Latreille, Wallis (1933) used this character in separating three species pairs: *H. leechi* and *H. salmo*, *H. subguttatus* Roberts and *H. salinarius* Wallis, and *H. immaculicollis* Harris and *H. robertsi* Zimmermann. Leech (1964) showed that relative eye separation was not a useful character in separating the second pair and noted an apparent sexual dimorphism in this character. Subsequently both the second and third pairs were synonymized (Vondel 1991, 2005).

MATERIALS AND METHODS

The minimum distance between the eyes, IO, and the maximum headwidth, HW, were measured using an ocular micrometer on a stereomicroscope (Wild M5, Leica MZ12.5). Specimens were positioned such that the structure being measured was parallel to the optical plane. Relative eye separation, R_{IO} was calculated by dividing IO by HW.

The holotypes and allotypes of *H. leechi* and *H. salmo* and the paratypes of these species in the Canadian National Collection of Insects (Ottawa, ON) were examined. The relative eye separation, R_{IO}, was meas-

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ured for both these specimens and a number of other specimens previously identified as *H. leechi* or *H. salmo*. Approximately a third of the males in these latter series were dissected to allow examination of the genitalia. The dissected genitalia were examined while they were floating in liquid, to prevent possible distortion due to drying and mounting. In addition, R_{IO} was measured for specimens identified as *H. subguttatus* and *H. canadensis* Wallis. The specimens examined are in the author's collection or were borrowed from the following museums: California Academy of Sciences (San Francisco, CA), D. Kavanagh; Canadian National Collection of Insects (Ottawa, ON), Y. Bousquet; J.B. Wallis Museum (University of Manitoba, Winnipeg, MB), R.E. Roughley; James Entomological Collection (Washington State University, Pullman, WA), R. Zack; Michigan State Collection of Insects (Michigan State University, East Lansing, MI), G. Parsons; Museum of Zoology, Invertebrate Section (University of Calgary, Calgary, AB), J.E. Swann; Spencer Entomological Museum (University of British Columbia, Vancouver, BC), K. Needham.

RESULTS AND DISCUSSION

Specific status of *H. leechi* and *H. salmo*. Wallis (1933) suggested that *H. leechi* and *H. salmo* could be separated by: i) background color, ii) maculation, iii) punctulation and iv) relative eye separation.

i) The color of preserved specimens is often more a function of their previous treatment than of the particular species involved (e.g. Kenner 2005). Wallis acknowledged this when he suggested that the color of the *H. salmo* type series may have "undergone some change" due to being recovered from the stomach of a trout. It is the current author's experience, based on the examination of large numbers of specimens belonging to the *H. leechi-H. salmo* complex, that the apparent background color is variable but the variation is not correlated with any other morphological character.

ii) One of the most obvious differences in the two holotypes is in the elytral maculation, with *H. leechi* having elytral blotches and *H. salmo* being immaculate. However, the maculation in *H. leechi* is variable, with some of the paratypes "losing almost all traces of spots on the elytra" (Wallis 1933). On most *H. leechi* specimens with very reduced maculation, one can still detect the position of at least some of the elytral blotches, due to infuscate 'halos' around the strial punctures in the appropriate positions. At least one of the *H. salmo* paratypes shows this same effect. It appears that there is a continuum in elytral maculation, with *H. salmo* being at one extreme and the putative subspecies *H. leechi carteri* Leech (1949) at the other. Note that the latter has since been synonymized with the nominate subspecies (Vondel 2005). The maculation of the head and thorax are similarly variable and do not provide a reliable character for separating *H. leechi* and *H. salmo*.

iii) Examination of a large number of specimens in the current complex suggests that the small differences in punctulation seen between the two holotypes is within the variation seen in the population as a whole and does not seem sufficient to justify erecting separate species.

iv) Wallis gives R_{IO} of the *H. leechi* and *H. salmo* holotypes as 0.46 and 0.54, respectively. The current author's remeasurement of the holotypes gives a smaller difference in R_{IO}: 0.48 and 0.51, respectively. The mean R_{IO}s for the two type series (*H. leechi*: holotype, allotype and nine paratypes; *H. salmo*: holotype, allotype and five paratypes) are 0.48 (range 0.46–0.50) and 0.51 (range 0.50–0.52), respectively. Wallis uses $R_{IO} < 0.50$ (*H. leechi*) and $R_{IO} \geq 0.50$ (*H. salmo*) in his key; this character does not even correctly separate all members of the two type series.

R_{IO} was measured for 142 specimens previously identified as either *H. leechi* or *H. salmo*; these specimens are from a vari-

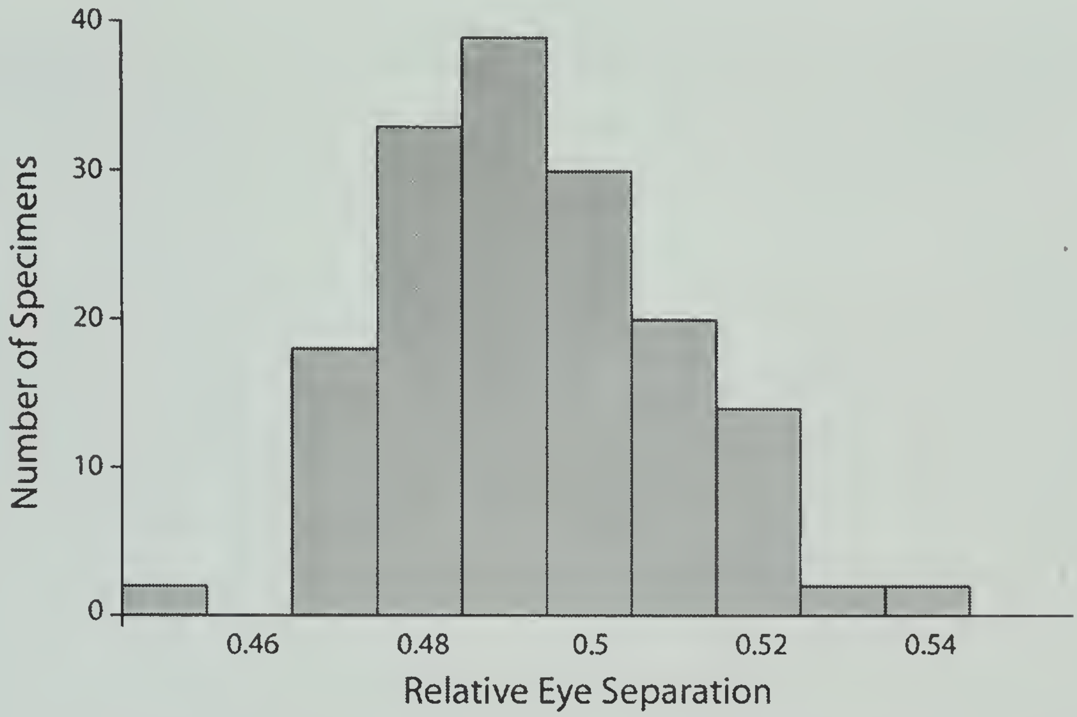

Figure 1. The frequency distribution of the Relative Eye Separation, R_{IO}, for specimens identified as *Haliplus leechi* and *H. salmo* including the type series for each. Wallis used $R_{IO} < 0.50$ = *H. leechi* and $R_{IO} \geq 0.50$ = *H. salmo* to separate the two species. R_{IO} for the holotypes of *H. leechi* and *H. salmo* are 0.48 and 0.51 respectively.

ety of localities. A histogram of R_{IO} from these specimens plus the specimens from the type series (Fig. 1), gives a unimodal distribution with a mean of 0.49 (range 0.44–0.54). It appears that there is a continuum in the values of R_{IO}, which suggests that it is not a good character for separating these two species.

This leaves possible differences in the male genitalia to separate these two species. The apparent differences in Wallis's drawings of the aedeagi are largely an illusion caused by the fact that Wallis did not draw the basal part of the aedeagus for *H. salmo*. If his two drawings are overlaid, one finds that the differences are on the order of a linewidth. Examination of the mounted genitalia of the two holotypes shows that the only significant difference is in the length of the digitus on the left paramere: longer in *H. salmo*. Due to possible distortions caused by drying and mounting, it is not clear if this difference is real. Examination of a large number of genitalia from both putative *H. leechi* and *H. salmo* specimens suggests that the difference is not constant.

Based on the similarity in the genitalia of the two holotypes and the apparent clinal nature of all other characters given by Wallis to separate these two taxa, *H. salmo* is placed as a junior subjective synonym of *H. leechi*. *Haliplus leechi* was chosen as the senior synonym to maintain stability in the literature as it is the much more widely recognized and cited name and to maintain the tribute to Hugh Leech intended by Wallis (1933).

Sexual dimorphism in the relative eye separation. In the data from the R_{IO} investigation discussed above, the smallest values of R_{IO} are from male specimens while the largest values are from female specimens, although there is extensive overlap. This suggests that R_{IO} may be sexually dimorphic. However, since headwidth is proportional to size and is smallest in males and largest in females, this could actually be a dependence on size rather than on sex.

To test for a possible sexual dimorphism in the relative eye separation, the specimens were sorted by HW and the mean value of R_{IO} for each size group was calculated separately for males and females. A paired *t*-test (Whitlock and Schluter 2009) with a null hypothesis of no difference in R_{IO} for males and females gives a mean R_{IO}(♂-♀) = -0.013 (t = -3.71, df = 15, P = 0.002). The

null hypothesis can be rejected with a high degree of confidence. Since males and females of the same size were compared, one can conclude that there is a sexual dimorphism in R_{IO} for *H. leechi*, with females averaging larger.

To determine if this is also true in other species, similar tests were performed for *H. canadensis* and *H. subguttatus*. For *H. canadensis*: mean R_{IO}(♂-♀) = -0.016 (t = -2.60, df = 8, P = 0.032); for *H. subguttatus*: mean R_{IO}(♂-♀) = -0.016 (t = -6.23, df = 10, P < 0.001). In both of these species the null hypothesis can be rejected with a high degree of confidence and a sexual dimorphism in R_{IO} is supported. Preliminary tests on other species suggest that this dimorphism may occur more widely in haliplids (Kenner unpublished). While the difference in R_{IO} for males and females of a given species are not large, one can end up with a situation, as the current author has, where males and females go to opposite sides of a couplet using R_{IO} as the primary character. Future keys should take this sexual dimorphism into account when the difference in R_{IO} is not large for the taxa being separated.

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The Harvestmen (Arachnida, Opiliones) of British Columbia

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ABSTRACT

Twenty species of harvestmen (six families within three suborders) are known from British Columbia. They are 1) Triaenonychidae: *Paranonychus brunneus*, *Sclerobunus nondimorphicus*; 2) Ceratolasmatidae: *Hesperonemastoma modestum*; 3) Sabaconidae: *Sabacon occidentalis*, *Sabacon* species, *Taracus* species; 4) Nemastomatidae: *Dendrolasma mirabile*, *Ortholasma pictipes*; 5) Sclerosomatidae: *Leiobunum exilipes*, *Leuronychus pacificus*, *Nelima paessleri*, *Togwoteeus biceps*; 6) Phalangiidae: *Leptobunus parvulus*, *Liopilio glaber*, *Odiellus pictus*, *Oligolophus tridens*, *Opilio parietinus*, *Paraoligolophus agrestis*, *Phalangium opilio* and *Rilaena triangularis*. Four are new records for BC: *O. parietinus*, *O. pictus*, the second *Sabacon* species, and the undetermined *Taracus* species. There are reports of two other species (Sclerosomatidae: *Hadrobunus grandis* and *Leiobunum aldrichi*) but these are probably incorrect. A further nine species have been collected from the Yukon or adjacent American states and may occur in the province. Each of these 31 species is listed along with information on its taxonomy and distribution. Updates on locations and earliest collection dates are also given for three species introduced into North America from Europe: *O. tridens*, *P. agrestis* and *R. triangularis*.

Key Words: Arachnida; Opiliones; Harvestmen; BC species

INTRODUCTION

Harvestmen (Opiliones) constitute an order in the class Arachnida. Harvestmen are characterized by having the prosoma and opisthosoma broadly fused (i.e. one rather than two body parts), chelate chelicerae, pedipalps that can be leg-like or very spiny, two medial eyes, a pair of scent glands on the anterior of the prosoma, and a penis or ovipositor. Unlike spiders (Araneae), harvestmen do not have silk glands or venom glands. Harvestmen are primarily predacious on small invertebrates, especially other arthropods, but are also scavengers of dead animals and occasionally feed on fleshy fruits. Opiliones is currently divided into four suborders: Cyphophthalmi, Laniatores, Dyspnoi and Eupnoi (Pinta-da-Rocha *et al.* 2007).

Knowledge of the species of Opiliones and of their distribution in British Columbia (BC) is very limited. Banks (1916) identified the first two species for the province. Over the years, various people added to the knowledge of this region (Roewer 1910 and 1923, Bishop 1949, Briggs 1971, Bragg and Leech 1972, Bragg and Holmberg 1975, Cokendolpher 1980). As the published records for harvestman of BC are scattered, taxonomic studies have resulted in changes in classification and nomenclature, and we have accumulated more specimens, we herein summarize the present knowledge of harvestmen in BC.

We believe that at least twenty species of harvestmen occur in BC. These are placed in three suborders (Laniatores, Dyspnoi and Eupnoi) and six families (Triaenonychidae, Ceratolasmatidae, Saba-

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conidae, Nemastomatidae, Sclerosomatidae and Phalangiidae). At least three, and up to five, of these species are introduced from Europe. There are reports of two other native species (*Hadrobunus grandis* and *Leiobunum aldrichi*) occurring in BC but these records are probably incorrect. Up to nine additional species may occur in the province. These nine species have been collected from adjacent states of the USA or the Yukon.

Most species listed here can be identified with the use of Edgar's key (1990). Bishop (1949) gives detailed descriptions of many species. Spoek (1963) and Hillyard and Sankey (1989) give good descriptions of the introduced European and Holarctic species. For general information on harvestmen, see Pinta-da-Rocha *et al.* (2007).

Species are listed alphabetically under the family or subfamily. Very limited synonymies are given in regular font following the current name in italics. The first reference listed is the original description. The last reference usually gives the best description of the species. Unless otherwise indicated, BC locality records are from specimens in our personal collections or in the three museums listed in the acknowledgements. The BC collection sites are usually given as simply the nearest geographical name. However a few localities originally given in miles were converted into kilometres (km). Unless otherwise stated, named parks are Provincial Parks. Distribution records from outside BC are from the literature as well as our records and are only designated by province, territory or state.

SPECIES RECORDS

Suborder LANIATORES Thorell 1876

Superfamily Triaenonychoidea Sørensen 1886

Family TRIAENONYCHIDAE Sørensen 1886

Subfamily Paranonychinae Briggs 1971

Paranonychus brunneus (Banks 1893)

Sclerobunus brunneus (Banks 1893)

Sclerobunus parvus (Roewer 1931 cited by Shear and Derkarabetian (2008))

Paranonychus brunneus (Briggs 1971)

Britannia Beach (Briggs 1971); Burnaby; Garibaldi Park (Briggs 1971); Grouse Mountain, Lake Cowichan (Vancouver Island; hereafter abbreviated VI); North Vancouver; Manning Park (Briggs 1971); Mount Seymour Park (Briggs 1971); Moresby Camp, Graham Island (Queen Charlotte Islands); Skedans, Louise Island (Queen Charlotte Islands); Sooke (VI); Upper Carmanah Valley (VI); Vancouver.

This species is also known from Alaska, Washington, and Oregon (Briggs 1971).

It is found under logs and in leaf litter of forests. Adults were collected in all months except January.

Subfamily Triaenonychinae Sørensen 1886

Sclerobunus nondimorphicus Briggs 1971

Sclerobunus nondimorphicus (Briggs 1971)

The only two BC records are from Hope (17 and 28 km east of), near Manning Park (Briggs 1971).

It is also known from Washington and Oregon (Briggs 1971).

This species has been collected from forests between June and September (Briggs 1971).

Suborder DYSPNOI Hansen and Sørensen 1904

Superfamily Ischyropsalidoidae Simon 1879

Family CERATOLASMATIDAE Shear 1986

Hesperonemastoma modestum (Banks 1894)

Nemastoma modesta (Banks 1894b)

Hesperonemastoma modestum (Gruber 1970)

Burnaby; Gordon River (VI); Honeymoon Bay (VI); Mesachie Lake (VI); Moresby Camp, Moresby Island (Queen Charlotte Islands); Nimkish Lake (VI); Vancouver.

This species is also known from Washington, Oregon and California

(Cokendolpher and Lee 1993).

This species is found under logs and in leaf litter. Adults were pitfall trapped from May through December.

Family SABACONIDAE Dresco 1970

Sabacon occidentalis (Banks 1894)

Phlegmacera occidentalis (Banks 1894b)

Sabacon occidentalis (Shear 1975)

Alert Bay (VI) (Bishop 1949); Brooks Peninsula (VI); Burnaby; Cassiope Lake (VI); Goldstream Park (VI); Honeymoon Bay (VI); Kyuquot (VI) (Shear 1975); Mesachie Lake (VI); Manning Park (Shear 1975); Parksville (VI); Prince Rupert (Bishop 1949); Skidgate, Graham island (Queen Charlotte Islands); Sooke (VI); Queen Charlotte City, Graham Island (Queen Charlotte Islands); Tahsis (VI); Upper Carmanah Valley (VI); Vancouver; Yakown River, Graham island (Queen Charlotte Islands).

This species is also known from Alaska, Washington, Oregon and California (Cokendolpher and Lee 1993). In Bragg and Leech (1972), this species was listed as *Sabacon crassipalpe*, which is now considered as only Eurasian (Shear 1975).

Sabacon occidentalis is found under logs and in leaf litter. Adults were collected in pitfall traps June through October.

Sabacon species

There is a second species of *Sabacon,* which occurs in northeastern BC, that will be described separately by RGH *et al.*

Pine Pass (129 km West of Dawson Creek).

Adults are present between April/May and October in Alberta.

Taracus species.

More specimens from BC and the United States need to be studied for a definitive identification.

Creston; Hourglass Cave, Gordon River (VI); Upper Carmanah Valley (VI).

This genus is characterized by very elongate chelicerae. Seven species have been described from the western United States (Cokendolpher and Lee 1993).

Adults were collected between September and October in BC.

Superfamily Nemastomatoidea Simon 1872

Family NEMASTOMATIDAE Simon 1872

Subfamily Ortholasmatinae Shear and Gruber 1983

Dendrolasma mirabile Banks 1894

Dendrolasma mirabilis (Banks 1894a)

Dendrolasma mirabile (Shear and Gruber 1983)

Burnaby; Mesachie Lake (VI); Metlakatla (Shear and Gruber 1983); Queen Charlotte City, Graham Island (Queen Charlotte Islands); Upper Carmanah Valley (VI); Vancouver.

This species is also known from Washington and Oregon and perhaps California (Shear and Gruber 1983). Edgar (1990) noted that this species ranges “from southern Oregon to southern Alaska”. However the most northern record (i.e. Metlakatla; Shear and Gruber 1983) is south of the BC-Alaska border. It may be premature to state that this species occurs in Alaska.

Dendrolasma mirabile is found in moist coniferous forests under logs and in leaf litter. Adults were collected June through August.

Ortholasma pictipes Banks 1911

Ortholasma pictipes (Banks 1911, Shear and Gruber 1983)

Alert Bay (VI) (Shear and Gruber 1983); Bamfield (VI); Goldstream Park (VI); Kyuquot (VI) (Shear and Gruber 1983); Skedans, Louise Island (Queen Charlotte Islands); Sooke (VI); Vancouver.

Ortholasma pictipes is also known from Washington, Oregon and California (Shear and Gruber 1983).

This species is found in coniferous forests under logs and in leaf litter. Adults collected from February through October.

Suborder EUPNOI Hansen and Sørensen 1904

Superfamily Phalangioidea Latreille 1802

Family SCLEROSOMATIDAE Simon 1879

Subfamily Leiobuninae Banks 1893

Hadrobunus grandis (Say 1821)

Phalangium grandis (Say 1821)

Hadrobunus grandis (Roewer 1923)

Roewer (1923, page 919) recorded this species from BC ("Brit Kolumbien: Vancouver-Stadt – 1 ♂ – (Mus. Wien …)". However, as noted by Cokendolpher and Lee (1993), this record is probably incorrect.

Hadrobunus grandis has been collected from Ohio, Illinois, Georgia, Maryland, North Carolina, Oklahoma and Virginia (Cokendolpher and Lee 1993).

Leiobunum aldrichi (Weed 1893)

Liobunum (*sic*) longipes (Weed 1890)

Leiobunum longipes (Davis 1934)

Leiobunum aldrichi (Cokendolpher 1984)

Bishop (1949) recorded "*Leiobunum longipes*" (now *Leiobunum aldrichi*; see Cokendolpher 1984) from "British Columbia, Selkirk Mts. (J.C.B)".

Although Roewer (1910, 1923) recorded this species from Washington and Weed (1893) recorded it from South Dakota, we think that this species does not occur in BC. Other than these old records, this species occurs in eastern North America (Ontario and 23 states) (Cokendolpher and Lee 1993).

Leiobunum exilipes (Wood 1868)

Phalangium exilipes (Wood 1868)

Leiobunum exilipes (Davis 1934)

Banks (1916) reported "Several specimens from Kaslo and Frye Creek [BC], from June 13 to July 23. These specimens have shorter legs than those from California." Davis (1934) recorded "*British Columbia*: Inverness, July 1 ♀ (Keen). Vancouver: 2 ♂, 1 ♀ (Banks)". RGH examined the Inverness specimen from the Canadian National Collection in Ottawa (single female labeled "Inverness", "July", "Rev. J.H. Keen" and identified by Davis). It is a dark *Nelima paessleri*. Older *N. paessleri* tend to darken and may resemble *L. exilipes*. Note that we have not seen any specimens of this species from BC.

Leiobunum exilipes is recorded from Alaska, Washington, Oregon, California, Nevada, and Montana (Cokendolpher and Lee 1993).

Adults have been collected between July and November (Davis 1934).

Leuronychus pacificus (Banks 1894)

Leiobunum pacificum (Banks 1894c)

Leuronychus pacificum (Banks 1900)

Leuronychus pacificus (Banks 1901, Roewer 1910, 1923)

Mudge Island; Nanaimo (VI) (Roewer 1910).

This species is also recorded from Alaska, Washington, Oregon, California and Baja California (Cokendolpher and Lee 1993).

Adults were collected from Mudge Island in August

Nelima paessleri (Roewer 1910)

Leiobunum paessleri (Roewer 1910, Davis 1934, Holmberg *et al.* 1984)

Nelima paessleri (Crawford 1992)

Alouette Lake; Brooks Peninsula (VI); Burnaby; Candlestick Cave, Kelsey Bay (VI); Cascade Cave, Port Alberni (VI); Cheakamus Lake; Cody Caves Park (north of Nelson); Field; Glacier; Gordon River (VI); Hope; Inverness; Horne Lake Caves Park (VI); Kimberly; Kuskonook; Meager Lake Hot Springs; Metlakatla (Davis 1934); Mount Kobau: Port Alberni (VI); Rogers Pass (Davis 1934); Salmon Arm; Slesse Creek and Chipmunk Caves (near Chilliwack); Sooke (VI); Stein Lake; Upper Carmanah Valley (VI); Victoria (VI); Vancouver; Wolfe Creek Cave (Cowichan Lake, VI).

Nelima paessleri is known also from Alberta, Alaska, Washington, Oregon, California, Montana and, possibly, Wyoming (Holmberg *et al.* 1984). We also have seen collections from Idaho.

This species has been collected from a wide range of forested habitats associated with coastal and interior mountains. Adults overwinter in aggregations in caves and mines (Holmberg *et al.* 1984). Adults are present all months of the year; juveniles between May and October. Sexes can only be distinguished by dissection of the genitalia.

Togwoteeus biceps (Thorell 1877)
Mitopus biceps (Thorell 1877)
Homolophus biceps (Rower 1923)
Togwoteeus biceps (Holmberg and Cokendolpher 1997)

Anarchist Mountain; Apex Mountain (near Keremeos); Inkaneep Park; Kamloops; Kleena Kleene; Manning Park; Mount Kobau; Oliver; Osoyoos; Salmon Arm; Summerland; Vernon; White Lake; Vaseaux Lake.

Togwoteeus biceps is known also from Alberta, Saskatchewan, Arizona, California, Colorado, Idaho, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming (Holmberg and Cokendolpher 1997).

This species is found in many habitats, from densely wooded areas to windswept mountain tops above the tree line. It occurs in dry areas but also near bodies of water. This species is restricted to higher elevations in the southern part of its range. It has been found under rocks and logs, and in deserted buildings. Adults occur between May and November with a peak in August. Immatures overwinter and can be present in any month (Holmberg and Cokendolpher 1997).

Family PHALANGIIDAE Latreille 1802

Subfamily Oligolophinae Banks 1893

Odiellus pictus (Wood 1868)
Phalangium pictum (Wood 1868)
Odiellus pictus (Bishop 1949)

The only record is Sitkum Creek, Nelson.

This species is widespread in all other Canadian provinces. It is also present throughout the northeastern USA (Cokendolpher and Lee 1993).

Odiellus pictus prefers wet locations in hardwood and coniferous forests, in meadows and marshes, in leaf litter and under rocks, and on the foliage of trees. Adults occur between July and October.

Oligolophus tridens (C.L. Koch 1836)
Opilio tridens (C.L. Koch 1836)
Oligolophus tridens (Spoek 1963, Hillyard and Sankey 1989)

Campbell River (VI) (our earliest records are from 1978); Comox (VI) (1979); Richmond (1971); Summerland (1980).

This species was introduced from Europe (Bell 1975). It is also in New Brunswick (1974), Newfoundland (1958), Nova Scotia (1956), Ontario (1961), Prince Edward Island (1972), Quebec (1970), as well as Maine (1982) and Vermont (prior 1974, Bell 1975).

This small species occurs mainly in the ground layer of many different disturbed habitats including grasslands, alfalfa fields, sand beaches as well as forests. Adults have been collected in Canada between July and November.

Paraoligolophus agrestis (Meade 1855)
Opilio agrestis (Meade 1855)
Paraoligolophus agrestis (Spoek 1963, Hillyard and Sankey 1989)

Ainsworth Hot Springs (1985); Burnaby (1971); Balfour (1980); Brentwood Bay (VI) (1975); Boswell (1980); Campbell River (VI) (1984); Comox (VI) (1984); Coombs (VI) (1984); Haney (1979); Hope (1984); Mesachie Lake (VI) (1979); Parksville (VI) (1978); Port Alberni (VI) (1979); Richmond (1971); Rogers Creek (1980); Vancouver (1963).

This is a European species introduced into BC by 1963 and Washington by 1972 (Bragg and Holmberg 1975). We now have single records from Alberta (1978) and Nova Scotia (1950).

The species is found in gardens and in forests under logs and in leaf litter, or on low bushes and herbs. Mature specimens occur between August and January.

Subfamily Phalangiinae Simon 1879

Leptobunus parvulus (Banks 1894)
Liobunum (sic) parvulum (Banks 1894c)
Leuronychus parvulus (Banks 1901)
Leptobunus parvulus (Cokendolpher 1985)

Alliford Bay, Moresby Island (Queen Charlotte Islands); Alouette Lake; Brooks Peninsula (VI); Burnaby; Cassiope Lake (VI); Coombs (VI); Cowichan Lake Experimental Station (VI); Golden Ears Park; Haney; Manning Park; Masset, Graham

Island (Queen Charlotte Islands); Port Alberni (VI); Squamish; Upper Carmanah Valley (VI); Vancouver.

Leptobunus parvulus is found also in Alaska, Washington, Oregon, and California (Cokendolpher 1985).

This species is active at night and can be found on low branches and shrubs and on the trunks of alders. Juveniles have been collected from the tops of 29 m tall red cedar, Douglas fir and Western hemlock trees (Holmberg *et al.* 1981). Juveniles were mostly collected May through August; adults, July through November.

Liopilio glaber Schenkel 1951

Liopilio glaber (Schenkel 1951, Cokendolpher 1981)

The only record from BC is “Mt. St. Paul, mile 392 [km 631] Alaska Highway” (Cokendolpher 1981).

Liopilio glaber is found also in the Rocky Mountains of Alberta, Washington and Oregon (Crawford and Edwards 1989, Cokendolpher and Lee 1993).

Adults were collected between July and September at higher elevations.

Opilio parietinus (DeGeer 1778)

Phalangium parietinum (DeGeer 1778)

Opilio parietinus (Spoek 1963, Hillyard and Sankey 1989)

Ainsworth Hot Springs; Kamloops; Kleena Kleene; Port Alberni (VI); Prince George; Summerland.

This species is widely distributed in the Western Palearctic and may have been introduced into North America from Europe. In Canada, it is known from Alberta, Manitoba, Saskatchewan, Ontario, and Quebec. It has also been collected from more than 20 states (Cokendolpher and Lee 1993).

Opilio parietinus was collected in disturbed areas similar to those for *Phalangium opilio. O. parietinus* was often collected with *P. opilio* but, with time, the latter seems to outcompete it. Adults from western Canada occur between July and November.

Phalangium opilio Linnaeus 1758

Phalangium opilio (Linnaeus 1758, Spoek 1963, Hillyard and Sankey 1989)

Ainsworth Hot Springs; Aspen Grove; Balfour; Barrière; Bella Coola; Blind Bay; Blue River; Burnaby; Cache Creek; Campbell River (VI); Chetwynd; Chilkoot Pass; Chilliwack; Comox (VI); Coombs (VI); Cranbrook; Creston; Dawson Creek; Edgewood; Elgin; Errington (VI); Fairmont; Fort Nelson; Fort St. John; Glacier National Park; Goldstream Park (VI); Grand Falls; Haney; Hazelton; Hernando Island; Hope; Hudson’s Hope; Kamloops; Kootenay National Park; Ladner; Liard River; Manning Park; Masset, Graham Island (Queen Charolotte Islands); Mesachie Lake (VI); Mica Creek; Mission; Mount Robson Park; Nakusp; Nanaimo (VI); Nelson; Nicola Lake; Oliver; Osoyoos; Parksville (VI); Paul lake (near Kamloops); Penticton; Port Alberni (VI); Pouce Coupe; Prince George; Queen Charlotte City, Graham Island (Queen Charlotte Islands); Quesnel; Skookumchuk; South Pender Island (VI); Summerland; Telkwa; Terrace; Tlell, Graham Island (Queen CharlotteIslands); Trutch; Vancouver; Vernon; Victoria (VI); Weir Beach (24km west of Victoria, VI); West Vancouver; Williams Lake; Yoho National Park.

Phalangium opilio occurs in all provinces of Canada, Yukon and Northwest Territories. It is also present in at least 17 US states as well as Europe, Asia, North Africa and New Zealand (Cokendolpher and Lee 1993). Although this harvestman is commonly collected in Canada, it is most likely introduced from Europe.

Phalangium opilio is found in disturbed areas, such as gardens and roadside ditches, as well as grasslands and forest edges. *Phalangium opilio* and *Togwoteeus biceps* are the two species most likely found in drier areas. Eggs are laid in the fall. The first juveniles are seen in early April. The first adults appear in June. The adults do not overwinter.

Rilaena triangularis (Herbst 1799)

Opilio triangularis (Herbst 1799)

Platybunus triangularis (Spoek 1963)

Rilaena triangularis (Hillyard and Sankey 1989)

Burnaby (1971); Coquitlam (1972); Haney; Pitt Meadows (1973); Sumas (1963); Terrace (1975); Vancouver (1967).

This species was introduced from Europe into BC and Washington (Bragg and Holmberg 1975). The earliest record that we have for Washington is 1951. It has also been collected from Maine (1986), Massachusetts (1999) and New York (1999).

R. triangularis matures in April to July in BC and England. In England, it lays its eggs during the summer and overwinters in a juvenile stage (usually third or fourth instar) (Hillyard and Sankey 1989). This species is found in disturbed areas, such as gardens, and at the edges of woods.

OTHER POSSIBLE SPECIES

Other species that have been collected from adjacent states and the Yukon and may be found in BC include:

Acuclavella cosmetoides Shear 1986 (Family Ceratolasmatidae) occurs in northern Idaho and Washington. Also *A. merickeli* Shear 1986 occurs in Idaho and Washington.

Liopilio yukon Cokendolpher 1981 (Family Phalangiidae) has been collected in Yukon and Alaska.

Metanonychus idahoensis Briggs 1971 (Family Triaenonychidae) is found in northern Idaho.

Mitopus morio (Fabricius 1779) (Family Phalangiidae) seems to be Holarctic in distribution. It is common in eastern North America but occurs also in Alaska (Cokendolpher and Lee 1993).

Protolophus niger Goodnight and Goodnight 1942 (Family Protolophidae) has been recorded from Washington and Oregon (Cokendolpher and Lee 1993).

Sclerobunus robustus idahoensis Briggs 1971 (Family Triaenonychidae) is found in northern Idaho.

Siro acaroides (Ewing 1923), of the fourth Opiliones suborder Cyphophthalmi, extends from California to Washington (Cokendolpher and Lee 1993). *Siro kamiakensis* (Newell 1943) occurs in northern Idaho and Washington (Cokendolpher and Lee 1993).

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Lady beetles (Coleoptera: Coccinellidae: Coccinellini) associated with Alaskan agricultural crops

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ABSTRACT

Adult coccinellid abundance was monitored in agricultural areas of the Tanana and Matanuska-Susitna River valleys of Alaska during 2004 and 2005. Thirteen species were collected in association with Alaskan agricultural crops. Of the species collected, *Hippodamia quinquesignata quinquesignata* (Kirby), *Coccinella transversoguttata richardsoni* Brown, and *Hippodamia tredecimpunctata tibialis* (Say) were by far the most abundant species, making up 51, 18, and 12%, respectively, of the individuals collected. Two new species, *Coccinella septempunctata* L. and *Hippodamia convergens* Guerin, were recorded for the first time in Alaska.

Key Words: lady beetles, biodiversity, integrated pest management, Alaska

INTRODUCTION

There has been much interest in the expansion of agricultural production in the circumpolar region in recent years (Anonymous 1998, 2001, Whitfield 2003). Alaska has tremendous agricultural potential, with approximately eight million hectares of arable land. However, the taxonomic identity, biology, population dynamics, and distribution of insect pests and their natural enemies in the circumpolar region is lacking or poorly understood (Pantoja *et al.* 2009). There is a need for increased research to improve management and to understand the biology of insect pests in arctic and subarctic regions. The development of pest management practices for Alaska is of particular interest since it is expected that insect populations in the state may increase with climate change (Whitfield 2003).

In recent years, USDA-ARS, in cooperation with the University of Alaska, has made efforts to develop integrated pest management (IPM) programs for Alaskan agricultural crops. However, some of the fundamental knowledge necessary to develop IPM systems is lacking. In Alaska, the beneficial insect complex associated with agricultural crops is not well known. Knowledge of the taxonomic identity and biology of beneficial insects is a critical component of IPM systems (Pedigo 1999). Published information on Alaskan coccinellids has been limited to distribution records within taxonomic treatments (Belicek 1976, Gordon 1985) and faunal lists (McNamara 1991). Additional research is needed to determine the taxonomic identity, distribution, and population dynamics of agriculturally beneficial insects in Alaska.

Coccinellids are commonly associated with biological control of pest species (Obrycki and Kring 1998). Members of the tribe Coccinellini are primarily aphidophagous (approx. 75-85%) (Hodek and Honěk 1996) and are easily recognizable in agricultural systems. Lady beetles have a wide distribution and occur in high numbers in agricultural habitats. Gordon's (1985) taxonomic monograph includes distribution maps and keys that include all Alaskan species. In addition Belicek (1976) and McNamara (1991) provide additional

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records for Alaska, but no studies have been conducted to survey the coccinellids associated with Alaskan agricultural crops. The purpose of this study was to provide baseline information on the species composition of coccinellids of the tribe Coccinellini associated with agricultural crops in Alaska.

MATERIALS AND METHODS

During 2004 and 2005 adult lady beetles of the tribe Coccinellini were surveyed in and around agricultural areas in the Tanana (near Nenana, N64.70° W148.86°; near Fairbanks N64.85°, W147.85°; near Delta Junction N64.15°, W145.81°) and Matanuska (near Palmer N61.57°, W149.25°) river valleys of Alaska. Sites in Fairbanks and Nenana were bordered by mixed boreal forest. Delta Junction sites were bordered by Conservation Reserve Program (USDA-NRCS) grasslands and boreal forest. Palmer sites were located in more developed rural areas adjacent to large-scale commercial agricultural lands.

Sampling was conducted in potato (*Solanum tuberosum* L.), rhubarb (*Rheum rhabarbarum* L.), and low-input mixed vegetable plantings. Beetles were captured by a variety of methods including Japanese beetle traps, yellow adhesive cards, water pan traps, sweep netting, and hand picking.

Japanese beetle traps (JBT) (Trece Catch Can, Trece Inc., Salinas CA) were placed in transects of three to five traps around field perimeters. Traps were installed by burying the cage-catch can in the ground so that only the top assembly was visible. In Palmer during 2004 and 2005, JBT's were maintained from mid-May to late August on a truck crop farm producing various vegetable crops. During 2004, 19 traps were placed around onion (*Allium cepa* L.), potato, squash (*Cucurbita* spp.), and rhubarb (*Rheum* spp.) plantings during mid-May and maintained until late August. During 2005, nine traps were initially placed around pea (*Pisum sativum* L.), rhubarb, and onion plantings on 10 May; an additional six traps were then added to potato and squash on 29 June. Additionally during 2005, five JBT's were maintained around potato fields at one location in Fairbanks and two locations in Delta Junction. Traps were serviced weekly; beetles were removed, transported to the laboratory, placed in 80% ethanol for temporary storage, pinned, labeled, and identified.

Adhesive cards (yellow; 0.041m^2; Intercept®; IPM Tech, Portland, OR) were placed along potato field margins in the Tanana and Matanuska valleys during both years of the study. Yellow adhesive cards (henceforth referred to simply as "cards") were stapled flat to a wooden stake with the bottom of the trap at canopy height and placed around potato field perimeters at a density of eight cards per hectare. During 2004 cards (n = 21) were placed at three locations in Fairbanks, one location in Delta Junction and three locations in Palmer. During 2005 cards (n = 40) were placed at two locations in Fairbanks, two locations in Delta Junction, two locations in Nenana, and three locations in Palmer. Cards were placed around field perimeters just prior to potato emergence (mid to late June) and maintained until first frost/harvest (late August to early September) during 2004 and first snow-fall (mid- to late October) during 2005. Cards were changed weekly; used cards were placed in 3.8 L plastic bags (Ziploc®, SC Johnson Company, Racine, WI), taken to the laboratory, and held in a freezer. Most beetles were identified *in situ* on the cards; problematic species were removed, washed in xylene, and examined in 80% ethanol.

Water pan traps, as described by Irwin (1980) and Villanueva and Peña (1991), were placed along potato field margins in the Tanana and Matanuska valleys during both years of the study. During 2004, traps (n = 24) were placed at three locations in Fairbanks, one in Delta Junction and three in Palmer. During 2005, traps (n = 41) were placed at two locations in Fairbanks, two locations in Delta Junction, one location in

Nenana, and three locations in Palmer. Traps were placed around field perimeters just prior to potato emergence (mid to late June) and maintained until first frost/ harvest (late August to early September) during 2004 and first snow-fall (mid- to late October) during 2005. Periodically during both years, additional pan traps were placed adjacent to small plantings of mixed vegetables and rhubarb at both Fairbanks and Palmer locations. Pan traps were changed bi-weekly and brought back to the laboratory where insects were strained from the soap solution and preserved in 80% ethanol.

Coccinellids were collected by hand picking when encountered at field sights to determine plant associations. Sweep net samples of 100 sweeps (four reps of 25 sweeps) were taken along potato field margins on a semi-weekly basis from locations in Fairbanks, Delta Junction, Nenana, and Palmer during 2005. Sweep net samples were not taken directly from potato foliage due to grower concerns about crop damage and to avoid possible mechanical spread of plant pathogens. Coccinellids, when inadvertently caught, were also collected from bucket style noctuid moth traps (Landolt *et al.* 2007).

Additionally, the University of Alaska Museum Insect Collection (UAM 2009) was examined to provide baseline information on coccinellid species in Alaska. The UAM includes the Washburn Insect Collection, which was amassed by USDA entomologists J. C. Chamberlin, R. H. Washburn, and others during the 1940's and 1950's. This collection, formerly housed in Palmer, AK, is the only large general insect collection maintained in the state (Washburn 1972).

All coccinellids were identified using taxonomic keys of Gordon (1985) and Gordon and Vandenberg (1991). Two representative individuals from most taxa were sent to Robert Gordon (retired, Systematic Entomology Laboratory, USDA) for identification confirmation. Voucher specimens were deposited in the UAM.

RESULTS AND DISCUSSION

During the field study, 1318 individuals representing 14 taxa were collected in or adjacent to agricultural habitats. Examination of the UAM revealed 196 individuals representing 10 taxa (Table 1). The majority of specimens at UAM were collected from the University of Alaska Fairbanks Research Farm in Palmer; however, label data for most specimens was insufficient to provide any meaningful agricultural crop associations. The field collected specimens included representatives of all species in UAM with the exception of *Anisosticta borealis* Timberlake and *Coccinella hieroglyphica mannerheimi* Mulsant that were not collected from the field. The most abundant species in the field collection, *Hippodamia quinquesignata quinquesignata* (Kirby), *Coccinella transversoguttata richardsoni* Brown, and *Hippodamia tredecimpunctata tibialis* (Say) were also numerous in the UAM Collection. *Macronaemia episcopalis* (Kirby), *Hippodamia falcigera* Crotch, *H. parenthesis* (Say), *H. convergens* Guerin, and *Coccinella septempunctata* L. were collected during the field study but no representatives were found in the UAM. Although the coccinellid species *Ceratomegilla ulkei* Crotch, *Hippodamia expurgata* Casey, *H. arctica* (Schneider), *H. sinuata spuria* LeConte, *Coccinella californica* Mannerheim, *C. johnsoni* Casey, *C. fulgida* Watson, *C. monticola* Mulsant 1850 and *Mulsantina hudsonica* (Casey) are listed for Alaska either singly or in combination by Belicek (1976), Gordon (1985), and McNamara (1991), these species were neither collected nor examined during this study (Table 1). The presence of these species in the state is uncertain. However, it is possible that they were not collected during this study due to its relatively narrow geographic scope or that the species are not associated with habitats commonly found near areas of agricultural production.

A total of 489 individuals representing

Table 1.
Lady beetle (Coccinellidae: Coccinellini) species listed from Alaska, numbers examined from University of Alaska Insect Collection (UAM) and numbers collected from the field during 2004 and 2005.

Taxon	Listed[1]	UAM	Field
Adalia bipunctata (L.)	4	18	45
Anatis mali (Say)	2,3	4	39
Anisosticta bitriangularis (Say)	4	5	3
Anisosticta borealis Timberlake	4	9	0
Calvia quatuordecimguttata (L.)	4	18	46
Ceratomegilla ulkei Crotch	4[2]	0	0
Coccinella californica Mannerheim	3	0	0
C. fulgida Watson	4	0	0
C. hieroglyphica mannerheimi Mulsant	4	4	1
C. johnsoni Casey	2,3	0	0
C. monticola Mulsant	3	0	0
C. septempunctata L.	-	0	7
C. transversoguttata richardsoni Brown	4	35	231
C. trifasciata perplexa Mulsant	4	7	53
Hippodamia arctica (Schneider)	4	0	0
H. convergens Guerin	-	0	43
H. expurgata Casey	2	0	0
H. falcigera Crotch	3	0	3
H. parenthesis (Say)	2,3	0	16
H. quinquesignata quinquesignata (Kirby)	4	11	677
H. sinuata spuria LeConte	4	0	0
H. tredecimpunctata tibialis (Say)	4	85	152
Macronaemia episcopalis (Kirby)	1,3	0	2
Mulsantina hudsonica (Casey)	1,3	0	0

[1] Belicek 1976 = 1; Gordon 1985 = 2; McNamara 1991 = 3; All 3 authors = 4.
[2] Listed as *Hippodamia ulkei* (Crotch) in Belicek 1976.

six taxa were collected from Japanese beetle traps during 2004 and 2005 (Table 2). Of those, *H. t. tibialis*, *H. q. quinquesignata*, and *C. t. richardsoni* were the most commonly collected taxa, making up 12, 51, and 18% of the total number of individuals collected respectively. *Hippodamia parenthesis*, *Adalia bipunctata* (L.), and *Coccinella trifasciata perplexa* Mulsant were collected in low numbers.

A total of 420 individuals representing 10 taxa were collected from yellow adhesive cards. *H. t. tibialis*, *H. q. quinquesignata*, and *C. t. richardsoni* were the most commonly collected taxa, making up 17, 62, and 13% of the total number of individuals collected respectively. *Hippodamia falcigera*, *H. parenthesis*, *H. convergens*, *Calvia quatuordecimguttata* (L.), *A. bipunctata*, *C. t. perplexa*, and *C. septempunctata* were collected in low numbers. No coccinellids were captured with cards at the Nenana locations during 2005. Due to staggered planting dates and other agronomic factors, data from different regions and study years could not be combined.

Coccinellids were collected sporadically in low numbers from pan traps during

Table 2.
Combined numbers of individuals of each taxon collected by all methods at each locality in the field study during 2004 to 2005.

Taxon	Location[1]				Date Range, All Locations
	F	D	N	P	
Adalia bipunctata (L.)	34	0	0	11	1 May -11 July
Anatis mali (Say)	39	0	0	0	10 May - 26 May
Anisosticta bitriangularis (Say)	1	0	2	0	22 June - 3 Aug.
Calvia quatuordecimguttata (L.)	31	0	1	14	10 May - 22 July
C. hieroglyphica mannerheimi Mulsant	0	0	0	1	28 July
C. septempunctata L.	6	0	0	1	19 July - 09 Aug.
C. transversoguttata richardsoni Brown	71	41	11	108	9 May - 6 Sept.
Coccinella trifasciata perplexa Mulsant	41	3	0	9	10 May - 12 Aug.
H. convergens Guerin	40	0	0	3	16 June - 13 Sept.
H. falcigera Crotch	1	0	0	2	9 June - 6 Sept.
H. parenthesis (Say)	3	4	6	3	9 May - 13 Sept.
H. quinquesignata quinquesignata (Kirby)	127	70	6	474	16 May - 9 Aug.
H. tredecimpunctata tibialis (Say)	55	1	4	92	10 May - 9 Aug.
Macronaemia episcopalis (Kirby)	0	1	1	0	21 July - 27 July

[1] Locations: F, Fairbanks; D, Delta Junction; N, Nenana; P, Palmer.

2004-2005 (Table 2). A total of 121 individuals representing nine taxa were collected. *H. t. tibialis*, *H. q. quinquesignata*, *H. convergens*, and *C. t. richardsoni* were the most commonly collected taxa, making up 19, 30, 17, and 19% of the total number of individuals collected respectively. *H. falcigera*, *H. parenthesis*, *C. quatuordecimguttata*, *A. bipunctata*, and *C. t. perplexa* were collected in low numbers. Insufficient numbers were collected of any taxon from any location to determine seasonal abundance. However, some crop associations can be made. *H. t. tibialis* were collected from potato (n = 7), rhubarb (n = 8), broccoli (*Brassica* spp.) (n = 1), and lettuce (*Lactuca sativa* L.) (n = 7); *H. q. quinquesignata* were collected from potato (n = 25), rhubarb (n=7), broccoli (n = 1), lettuce (n = 2), and tomato (*Solanum lycopersicum* L.) (n = 1). *C. t. richardsoni* was trapped from potato (n = 12), rhubarb (n = 3), broccoli (n = 3), lettuce (n = 3), and mixed vegetables (n = 2). *H. convergens* was collected from potato (n = 1), tomato (n = 3), and pansies (*Viola* spp.) (n = 16).

A total of 107 individuals representing 11 taxa was collected by sweeping along potato field perimeters during 2005 (Table 2). *H. t. tibialis*, *H. parenthesis*, *H. q. quinquesignata*, *C. trifasciata perplexa*, and *C. transversoguttata richardsoni*, were the most commonly collected taxa, making up 15, 9, 14, 15, and 37% of the total number of individuals collected respectively. Additionally, *A. bitriangularis*, *M. episcopalis*, *H. falcigera*, *Anatis mali* (Say), *C. quatuordecimguttata*, and *A. bipunctata* were collected in low numbers from herbaceous vegetation along potato field margins.

A total of 166 individuals representing 11 taxa were collected from foliage by hand picking (Table 2). *H. t. tibialis* was collected from rhubarb and lettuce. *H. q. quin-*

quesignata was collected from a wide variety of plants including eggplant (*Solanum melongena* L.), lettuce, potato, and rhubarb. *H. convergens* was collected from banana peppers and potato. *C. t. richardsoni* was collected from potato and tomato. *C. t. perplexa* was collected from eggplant, and rhubarb. During early May large numbers of *C. quatuordecimguttata* (n = 32), *A. mali* (n = 36), *A. bipunctata* (n = 27), *C. t. perplexa* (n = 13) were collected from European bird cherry (*Prunus padus* L.) near agricultural areas.

Although not directly comparable due to differences in numbers of field sites and sampling days in each region, little difference was noted in the relative abundance or species composition between the Tanana and Matanuska valleys. This is unexpected because the Matanuska valley is well known for its relatively mild climate compared to that of the Tanana valley in the interior. The majority of lady beetles was collected from Fairbanks and Palmer reflecting the relatively heavy collecting compared to other areas. In Delta, only one field site was sampled during 2004 and two sites during 2005. Relatively few specimens were collected during 2005 from the two sites in Nenana.

Hippodamia convergens and *C. septempunctata* are documented in Alaska for the first time (Table 1). Distribution maps of Acorn (2007) indicate the presence of *C. septempunctata* in the state; however, the source of the record is unstated and probably based on speculation.

Hippodamia convergens is found throughout the USA and southern Canada (Gordon 1985). *H. convergens* was collected in small numbers during both years of the study (Table 1) in association with potato and mixed vegetables (Table 2). Since *H. convergens* is commonly available commercially and was collected near population centers (Fairbanks and Palmer), it is assumed that these specimens are a result of private biological control releases. It is unclear at this time whether *H. convergens* is established in Alaska.

Coccinella septempunctata is one of several species of coccinellids propagated and released throughout the west by the USDA Animal and Plant Health Inspection Service for control of Russian wheat aphid (*Diuraphis noxia* [Mordoviko]) (Gordon and Vandenberg 1991). This species had been implicated in declines in abundance of native coccinellid species (Wheeler and Hoebeke 1995, Elliot *et al.* 1996, Alyokhin and Sewell 2004). The presence of this species in the study area is most likely the result of a natural range extension or accidental release because it is not readily available commercially (Hoffmann and Frodsham 1993). The apparently recent occurrence of *C. septempunctata* in Alaska should provide a unique opportunity to study its impact on native coccinellids in the state.

During this study members of the subspecies *H. t. tibialis, H. q. quinquesignata*, and *C. t. richardsoni* were collected in highest numbers in association with agricultural crops. Of those species, *H. q. quinquesignata* was, by far, the most abundant, representing 51% of the total number of individuals collected during the field study. Due to their abundance in or around agricultural areas, *H. t. tibialis, H. q. quinquesignata*, and *C. t. richardsoni* show the most potential as naturally occurring biological control agents in Alaskan agricultural systems. However, their role in Alaskan agricultural systems is in need of further study. Additional research is needed to determine seasonal abundance, habitat preference, and biology of these species in the state.

C. septempunctata has been reported to be invasive in some areas, displacing native species; its future impact on Alaskan coccinellid diversity should be monitored. *H. convergens* is available commercially in the state and its ability to overwinter is unknown.

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Ground beetles (Coleoptera: Carabidae) associated with Garry Oak Ecosystems on Southern Vancouver Island, British Columbia

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ABSTRACT

The ground beetle populations under 60% Garry Oak forest cover at Mary Hill and Rocky Point on the Southwest fringe of Vancouver Island were assessed in September/ October 2003 using pitfall traps. Two groups of five pitfall traps were set out at each location and collected weekly. The dominant species recovered was *Pterostichus algidus* which made up more than 75% of the insects caught at Mary Hill and more than 90% of the insects caught at Rocky Point. Thirteen species of carabid beetles were recorded.

INTRODUCTION

Garry oak (*Quercus garryana* Dougl.) ecosystems of Southern Vancouver Island constitute a biodiversity hotspot in British Columbia. This study is a contribution to define the inventory of ground beetles (Coleoptera: Carabidae) in areas that contained at least 60% Garry oak. The study area occurs within the Coastal Douglas-fir Zone (CDFmm) near its western (wetter) limits. This biogeoclimatic zone is restricted to low elevations (<150m) along southeast Vancouver Island, the southern Gulf Islands and a small portion of the nearby mainland. The zone is characterized by warm, dry summers and mild, wet winters and has the mildest climate in Canada. Forests of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), often with a secondary component of grand fir (*Abies grandis* Dougl. Ex D. Don) or western redcedar (*Thuja plicata* Donn ex D. Don), tend to dominate well-drained sites with medium textured soils. Drier sites, such as our study area, are dominated by Garry oak and/or arbutus (*Arbutus menziesii* Pursh) (Green and Klinka, 1994).

The Rocky Point area is close to a large concentration of First Nations' (aboriginal) burial cairns and was almost certainly on the edge of a major First Nations village. Both the Rocky Point and Mary Hill sites have been logged. Most of the Garry oak stands, especially along the western part of the CDF, were fire maintained for centuries and are now reverting to Douglas-fir – hence the spreading canopies of many of the Garry oak trees indicating that they grew in an open meadow (Fairbarns, 2008).

Ground beetles (Coleoptera: Carabidae) have been widely used in recent years as one of the indicators of forest change in Canada, especially in measuring the impacts of various harvesting regimes. In general, pitfall trapping of arthropods is more a measure of activity than density (Work *et al.* 2008). The taxonomic support for the Carabidae in Canada and North America is provided by an extensive set of keys developed by Lindroth (1963-9). The biological notes for these species have been summarized by Larochelle and Larivière (2003). The objective of this study was to determine the ground beetle species richness in a relatively undisturbed Garry oak dominated ecosystem.

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MATERIALS AND METHODS

Study Locations. Two locations within the Department of National Defence lands on Southwestern Vancouver Island, that had greater than 60% Garry oak cover, were selected as secure trapping areas for this study. One was in the vicinity of Mary Hill (48°20'32"N, 123°32'50"W) and the other was near Rocky Point (48°19'20"N, 123°32'30"W). In each area, two trapping sites were set up (MH1 and MH2 at Mary Hill and RP1 and RP2 at Rocky Point) approximately 100 m apart. At each site, 5 pitfall traps were set out in a semicircle. Inter-trap distances were ~25m. The hole for the pitfall trap was excavated with a bulb planter that resulted in minimal disturbance of the litter layer that reduced digging-in effects (Greenslade, 1973). Two plastic 500mL plastic cups (8cm lip diameter and 10cm deep) were inserted into the holes with the upper (inner) cup lip at the litter level. The outer cup retained the soil allowing easy removal of the inner cup for sample collection. The 75mL of polypropylene glycol was changed at each collection. Each trap was covered with a 30 cm square of marine plywood supported on 3cm risers at each corner to act as a rain and debris cover. Traps were set out on September 7th, 2003 and collected each week until October 5th, 2003.

Three of the sites (MH1, MH2 and RP1) were in vernally moist meadows overrun by robust exotic grasses. Each was surrounded by Garry oak in various mixtures with arbutus, grand fir and Scotch Broom (*Cytisus scoparius* (L.)). RP2 differed in that mature grand fir, Douglas-fir, arbutus and Garry oak dominated the site and the pitfall traps were set in the litter layer under these tree canopies where there was the lightest presence of grasses. The Rocky Point sites were within 100m of the rocky shoreline while the Mary Hill Sites were more than 500m inland.

Vegetation Survey. A qualitative survey was made of the dominant species in each site as well as some detail of the vegetation around each pitfall trap. These data were especially useful for evaluating species which showed restricted distributions.

Data Analyses. Sørenson's C_s similarity index (Southwood and Henderson 2000) was used to compare species richness between sites within locations and between locations, where $C_s = 2J/(2J+A+B)$, and A = number of species unique to Site A; B = number of species unique to Site B and J = the number of species common to both. This index ranges from 0.0, no common species, to 1.0, all species being common to the two samples, and has been rated as one of the better similarity measures by Smith (1986). Rank order abundance plots (Southwood and Henderson 2000) were made to demonstrate level of species abundance and richness at each site. ANOVA was used to compare *Pterostichus algidus* numbers among collecting locations and weeks. Tukey's Test was used for pairwise comparisons (Statistix 7, 2000).

RESULTS AND DISCUSSION

A total of 1188 ground beetles, in 13 species, were collected with the dominant species (*Pterostichus algidus)* making up more than 85% of the total catch (Table 1). Significantly greater numbers of *P. algidus* were caught on the Rocky Point sites than on the Mary Hill sites. Lower numbers of *P. algidus* were caught in the second week when the mean daily temperature was lower and the highest weekly rainfall was recorded (Fig. 1, Table 2). *P. algidus* is known as a species that is common in mixed forests and has been noted above sea beaches, as we found in RP1 and RP2 (Larochelle and Larivière 2003).

The second most abundant species captured was *Trechus obtusus* (Table 1) that was found in both locations but notably absent from RP2, where traps were set out in the litter layer and the grasses were sparse. In the other three sites, with the vernally moist meadows, traps that caught the

Table 1.
Numbers of ground beetles captured at each study site ordered by total numbers of individuals captured.

Species	Location (Pitfall Trap Weeks)				Total
	Mary Hill 1 (20)	Mary Hill 2 (19)	Rocky Point 1 (20)	Rocky Point 2 (20)	
Pterostichus algidus LeConte	187a[1]	128a	343b	361b	1019
Trechus obtusus Erichson[2]	9	6	49	0	64
Calathus fuscipes (Goeze)[2]	27	12	0	0	39
Carabus nemoralis O.F. Müller[2]	8	12	0	0	20
Zacotus matthewsii LeConte	0	8	5	1	14
Harpalus cautus Dejean	4	0	5	0	9
Scaphinotus angusticollis (Fisher von Waldheim)	2	2	0	3	7
Pterostichus herculaneus Mannerheim	0	0	0	5	5
Scaphinotis marginatus (Fisher von Waldheim)	0	1	4	0	5
Harpalus somnulentus Dejean	0	3	0	0	3
Harpalus affinis (Scrank)	0	1	0	0	1
Omus dejani Reiche	0	1	0	0	1
Poecilus lucublandus Say	1	0	0	0	1
Totals	**238**	**174**	**406**	**370**	**1188**

[1] Significantly more *Pterostichus algidus* captured at Rocky Point than at Mary Hill ANOVA, Tukey's Test, ($p<0.001$).
[2] Species noted as of recent European origin (Spence and Spence 1988)

Table 2.
Average weekly catch per trap of *Pterostichus algidus* and associated weekly weather data (as recorded at William Head, Environment Canada).

For week ending	Average number *P. algidus*/trap/week	Average daily temperature °C	Total weekly rainfall (mm)
September 14th	13.6a[1]	13.6	5.6
September 21st	7.4b	12.9	6.8
September 28th	17.1a	15.2	0
October 5th	12.9a	13.8	0

[1] Significantly fewer *P. algidus* captured in the second week, ANOVA, Tukey's Test, $p<0.001$.

highest numbers of *T. obtusus* were in grassy areas near the edge of overstory canopies. Scotch broom was also noted near these traps. The next two most abundant species, *Calathus fuscipes* and *Carabus nemoralis,* were confined to the Mary Hill sites. These two species (as well as *T. obtusus*) were recorded by Spence and Spence (1988) as being of recent European origin. The sex ratios (males per female) for the four most numerous species (see Table 1) were 0.90, 0.45, 0.29, 0.50 respectively

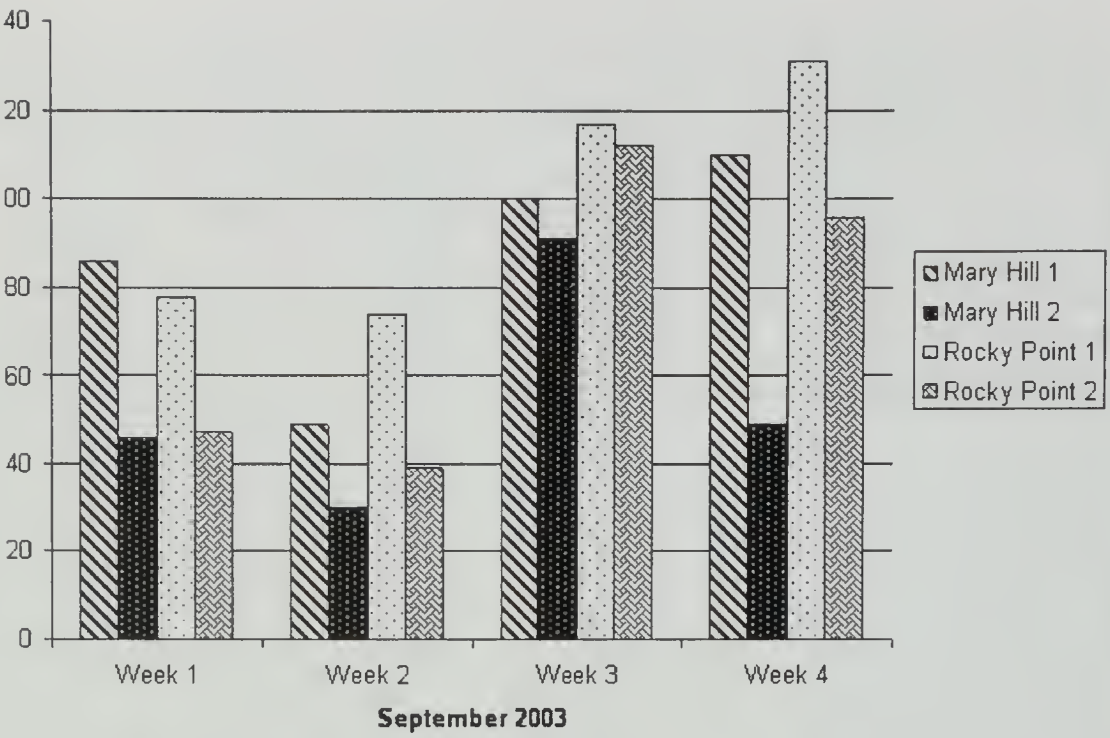

Figure 1. Total numbers of beetles captured in pitfall traps set out on DND Lands, Vancouver Island in September/October 2003 (5 traps per location).

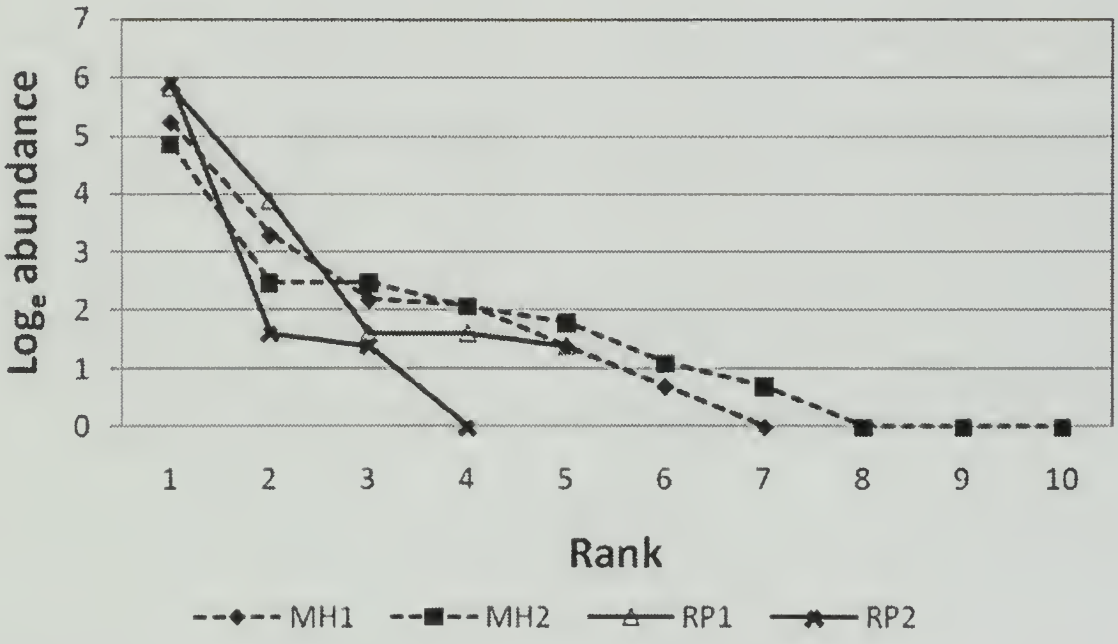

Figure 2. Rank order abundance plots for the carabid communities at Mary Hill and Rocky Point, Southern Vancouver Island, September/October 2003.

showing that more females than males were captured.

The similarity coefficients (Table 3) were calculated to compare catches for sites within locations (MH1,MH2; RP1,RP2) and between locations (MH,RP). Six of the 7 species captured at the Rocky Point sites were also caught at Mary Hill which resulted in a higher similarity index for the two locations than between sites in the same location. The rank order abundance plots (Fig. 2) show that a single species (see *P. algidus* in Table 1) dominated all catches.

A major concern in developing efficient biodiversity conservation is knowing the biodiversity already present and something of its distribution (Leather *et al.* 2008). This brief study documents the species that are active in the fall in a Garry oak community. The three exotic species from Europe are well established in the area.

Table 3.
Similarity indices for the ground beetle catches at Mary Hill and Rocky Point. Based on data in Table 1.

	Parameters[1]			
Comparison	**A**	**B**	**J**	**Sørensen Coefficient (Cs)**
Mary Hill 1 vs Mary Hill 2	2	5	5	0.588
Rocky Point 1 vs Rocky Point 2	3	2	2	0.444
Mary Hill vs Rocky Point	6	1	6	0.632

[1] Parameters for the Sørenson Coefficient (Cs): A = Unique species in first group, B = unique species in second group, J = species in both groups being compared.

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Ground beetles (Coleoptera: Carabidae) of Stanley Park, Vancouver, British Columbia following the storms of December 2006

JOHN A. McLEAN[1,2] and AGNES LI[1]

ABSTRACT

Ground beetles in Stanley Park were surveyed using pitfall traps in two areas in 2007 that had little damage from the 2006 winter storms and in two areas in 2008 after extensive windfall material had been cleared away and the sites replanted. The most numerous species trapped were *Pterostichus algidus*, *P. herculaneus*, *P. lama* and *Scaphinotus angusticollis*. Seasonal patterns of occurrence and rank order abundance plots are presented.

INTRODUCTION

Winds exceeding 110 km/h during the winter storms of 2006/2007 caused massive areas of blow down in the forests of Stanley Park, a prized recreational and educational area in the city of Vancouver. Stanley Park is Vancouver's oldest and largest park. It was opened by Lord Stanley, Earl of Preston, the Governor General of Canada in 1888 (Steele 1988). The central feature of the park is the 300 ha of uneven-aged coastal temperate rainforest that is largely classified under the BEC system as CWHdm (Green and Klinka 1994). Stanley Park was the site of several First Nations (aboriginal) villages before the arrival of Europeans in the 19th century. The forest was selectively logged between 1860 and 1880 and later protected from further development when it was designated as a military reserve (Vancouver Park Board 2003-09).

The first records of insects in Stanley Park were made by Swaine (1914). Major control operations were carried out in Stanley Park for the western hemlock looper, *Lambdina fiscellaria lugubrosa* (Hulst) in 1930 and again in 1959 when there was an outbreak of the western hemlock looper and the greenstriped forest looper, *Melanolophia imitata* (Walker) (Richmond, 1986). The most recent control program was against the Asian Gypsy Moth, *Lymantria dispar* L. in 1992 (Van Sickle and Wood, 1994). Humble (2008) reported that 99 species of beetles, 122 species of moths and 11 species of sawflies have been recorded from Stanley Park and adjacent forest habitats on the North Shore by the Forest Insect and Disease Survey between 1949 and 1995.

A restoration plan was developed to guide the recovery of the park after the 2006/07 winter storms (Vancouver Park Board 2007). As part of the restoration plan, seasonal surveys of the moths were carried out (deWaard *et al.* 2009) as well as trapping for bark beetles and wood borers with semiochemical-baited traps. A series of pitfall traps were set out to survey epigaeic fauna. The rove beetles (Coleoptera:Staphylinidae) caught in these traps and in the funnel traps have been listed by McLean et al. (2009a, b). The objective of this study is to report the results of the seasonal survey of the carabid ground beetles in undamaged areas in 2007 and to compare patterns of occurrence with areas where extensive blow down had been removed and areas replanted in 2008.

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MATERIALS AND METHODS

The Study Areas. In 2007, a stand by the Vancouver Aquarium (49°18'02"N, 123°07'04"W) (Fig. 1, Site A) with a small amount of blow down (Fig. 2A) was designated as a natural disturbance site where no restorative actions would be undertaken. The second study site for 2007 was an undamaged mixed-age conifer forest to the east of Rawlings Trail south of the Hollow Tree (49°18'22"N, 123°09'11"W) (Fig. 1, Site B). This site experienced damage from Hurricane Freda in 1962 and has immature trees from that time as well as mature trees that survived the hurricane (Fig. 2B). The 2008 study sites included a stand to the west of the South Creek Trail (49°18'03", 123°08'25"W) (Fig. 1, Site C) which had been logged and also burned in the 1860 fire. The high stumps (Fig. 2C) are a remnant from that period. The site was cleared of all fallen trees and replanted in the fall of 2007 with clumps of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and western redcedar (*Thuja plicata* Donn). The second 2008 study site along Merilees Trail (Fig. 1,Site D) (49°18'40"N, 123° 09'02"W) had also been cleared and replanted in the same manner as Site C (Fig. 2D).

Field Collections. In 2007, five pitfall traps were set out in each of Sites A and B. These traps were set out in association with a series of semiochemical-baited multiple funnel traps set out at 25m intervals to survey bark beetles and wood borers. In 2008, a sixth baited multiple funnel trap was added to the survey along with a sixth pitfall trap in Sites C and D. Cavities for the pit fall traps were excavated with a bulb planter. This allowed for minimal disturbance of the litter layer and the installation of two plastic 450mL plastic cups, 8 cm lip diameter and 10 cm deep, that were inserted so that the inner cup lip was at litter level. The outer cup retained the soil allowing easy removal of the inside cup for sample collection. The 75mL of polypropylene glycol was changed at each collection. Each pitfall trap was covered by a 30 cm by 30 cm square of marine plywood supported on 3 cm risers on each corner to act as a rain and debris cover. Phillips and Cobb (2005) showed that opaque covers over pitfall traps do not adversely affect carabid catch rates. Traps were set out in 2007 on April 20th and collected every two weeks until the end of August. In 2008, traps were set out on April 23rd and collected monthly until the end of October.

Sample analyses. Samples were sorted at UBC Forestry and the ground beetles identified with the aid of the Lindroth (1961-69) keys to the ground-beetles of Canada and Alaska. Total catches for each year were tabulated and a rank abundance graph (Southwood and Henderson 2000) was prepared for each site to demonstrate species abundance and species richness. Graphs of the seasonal occurrence of the dominant species were also prepared.

Sørenson's similarity coefficient (C_s) (Southwood and Henderson 2000) was determined among all sites. $C_s = 2J/(2J + A + B)$ where A = the number of species unique to Site A, B = the number of species unique to Site B and J = the number species common to both. This index is rated as one of the better similarity measures by Smith (1986).

RESULTS AND DISCUSSION

A total of 629 carabid beetle specimens (15 species in 8 genera) were captured, of which only 10 specimens (3 species in 3 genera) were non-native. The most numerous species collected in 2007 at Sites A and B were *Pterostichus algidus* LeConte and *P. herculaneus* Mannerheim. At Site B, moderately large numbers of the larger species *Scaphinotus angusticollis* (Fischer von Waldheim) and *P. lama* (Ménétriés) were also collected (Table 1); see also the rank abundance curves for 2007 (Fig. 3). In 2008, *P. herculaneus* and *S. angusticollis* were the more numerous species at Site C

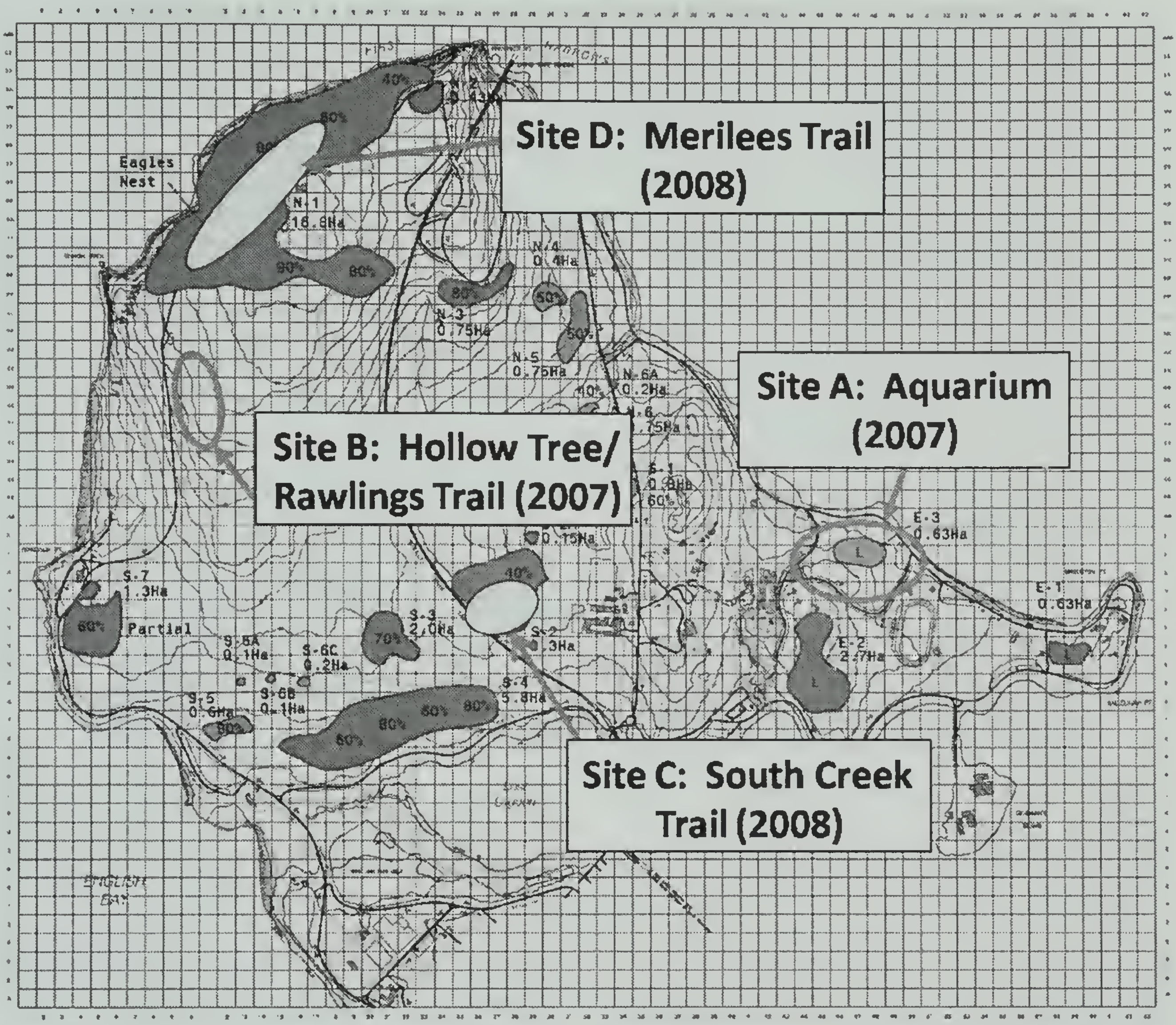

Figure 1. Map of Stanley Park showing the locations of pit fall traps in 2007 and 2008.

while *P. algidus* and *P. herculaneus* were more numerous at Site D (Table 1). The major difference between Site C and the other three sites was that the duff layer in Site C had been considerably disturbed during log removal and the subsequent fine woody debris redistribution activities. The rank abundance curves for 2008 show that two species were dominant on sites C and D (Fig. 3). Just three non-native species, *Carabus nemoralis* O.F. Müller, *Calathus fuscipes* (Goeze) and *Pterostichus melanarius* (Illiger), were captured over the two years. Sørenson's coefficients between pairs of sites (Table 2) showed considerable commonality of species in this CWHdm environment of Stanley Park.

Other ground beetles captured included *Calathus fuscipes* (Goeze), *Lebia marginicollis* Dejean, *Leistus ferruginosus* Mannerheim, *Notiophilus sylvaticus* Eschscholtz, *P. crenicollis* LeConte, *S. angulatus* (T.W. Harris), *S. marginatus* (Fischer von Waldheim) and *Trachypachus holmbergi* Mannerheim.

Pterostichus herculaneus was caught most consistently throughout the trapping period on each of the four study sites with individuals being caught during each collecting period (Fig. 4). Johnson *et al.* (1966) reported this species in a dense stand of Douglas-fir as well as a recently logged stand in Washington State and that it fed readily on Douglas-fir seed. Niwa and Peck (2002) recorded consistent activity of *P. herculaneus* from July through October in a Douglas-fir forested area in Oregon.

Very few *Pterostichus algidus* were captured in July of both years (Fig. 4). This species is more active in the spring and fall. Very low catches were recorded at Site C which was the most disturbed site as a re-

Figure 2. Photographs of study sites with pit fall traps to survey ground fauna in 2007 and 2008. A. A stand near the Vancouver Aquarium (2007); B. The forest to the eastern side of Rawlings Trail south of the Hollow Tree (2007); C. The cleared forest to the west of the South Creek Trail (2008); D. A view of the restored area along Merilees Trail (2008).

sult of repeated traveling of heavy logging equipment over the same trails even though brush mats were used. Another taxon that showed a similar reduction in catch numbers at Site C was the Isopoda, dominated by the wood louse *Oniscus ascellus* L. (Isopoda: Oniscidae) where we collected 894, 83, 43 and 313, at Sites A, B, C and D respectively, during the same collecting periods.

Pterostichus algidus was reported by Johnson *et al.* (1966) to have a similar temporal catch profile in Washington State and that the beetle was a consistent eater of Douglas-fir seed. The larger *Pterostichus lama* was trapped most frequently in the June/July period at both Site B (2007) and Site C (2008) (Fig. 4). Johnson *et al.* (1966) reported that *P. lama* would eat Douglas-fir seed only as a last resort. We have no additional data on this species' trophic relationships. The largest catches of *S. angusticollis* were in the fall of 2007 at Site B and in the fall of 2008 at Site C (Fig. 4). *S. angusticollis* is reported as feeding on snails, slugs, earthworms and spiders (Larochelle and Larivière 2003) as well as juvenile western red-backed salamanders (*Plethodon vehiculum* Cooper) in captivity (Ovaska and Smith 1988). Ovaska and Smith (1988) further noted that *S. angusticollis* preferred slugs <25 mm long, the larvae feed on live snails and adults will feed only on crushed snails.

A search among rotting logs on Site A in February 2008 found two overwintering *P. algidus* along with a large number *O. ascellus* and a small colony of dampwood termites, *Zootermopsis angusticollis* (Hagen) (Isoptera: Hodotermitidae). The two *P. algidus* were placed in a small terrarium with rotting wood, 5 wood lice and 5 termite nymphs along with one soldier termite as well as two piles of 10 Douglas-fir seed. The soldier termite was eaten, one wood louse was dismembered and one and a half seeds were eaten over a six week period. More accurate detailed feeding studies should be carried out to fully characterize the ecological niche of the ground beetles, including the habits of developing larvae, if we are to more fully appreciate

Table 1.

Ground beetles captured in Stanley Park in 2007 (April to October) and 2008 (May to October), n = number of pit fall traps per site.

Rank	Site A: Aquarium 2007 (n = 5)			Site B: Hollow Tree 2007 (n = 5)			Site C: South Creek Trail 2008 (n = 6)			Site D: Merilees Trail 2008 (n = 6)		
		#	%		#	%		#	%		#	%
1	*Pterostichus algidus*	75	58.6	*P. algidus*	63	35.8	*P. herculaneus*	66	47.8	*P. algidus*	81	43.8
2	*Pterostichus herculaneus*	44	34.4	*P. herculaneus*	62	35.2	*S. angusticollis*	49	35.5	*P. herculaneus*	74	40.0
3	*Notiophilus sylvaticus*	3	2.3	*S. angusticollis*	22	12.5	*P. lama*	13	9.4	*S. angusticollis*	9	4.9
4	*Scaphinotus marginatus*	3	2.3	*P. lama*	20	11.4	*P. algidus*	4	2.9	*C. nemoralis*[1]	7	3.8
5	*Calathus fuscipes*[1]	1	0.8	*L. ferruginosus*	2	1.1	*S. angulatus*	2	1.4	*Harpalus cordifer*	4	2.2
6	*Leistus ferruginosus*	1	0.8	*S. angulatus*	2	1.1	*S. marginatus*	2	1.4	*P. crenicollis*	3	1.6
7	*Scaphinotus marginatus*	1	0.8	*S. marginatus*	2	1.1	*Lebia marginicollis*	1	0.7	*P. lama*	2	1.1
8				*Carabus nemoralis*[1]	1	0.6	*N. sylvaticus*	1	0.7	*L. marginicollis*	1	0.5
9				*P. crenicollis*	1	0.6				*N. sylvaticus*	1	0.5
10				*P. melanarius*[1]	1	0.6				*S. angulatus*	1	0.5
11										*S. marginatus*	1	0.5
12										*Trachypachus holmbergi*	1	0.5
Totals		128	100		176	100		138	100		185	100

[1] Species of recent European origin in British Columbia (Spence and Spence 1988)

Table 2.
Sørenson's coefficient (C_s) for pairwise comparisons of the species similarity between the four sites sampled in 2007 and 2008 in Stanley Park.

	Site B (2007)	Site C (2008)	Site D (2008)
Site A (2007)	0.63	0.67	0.53
Site B (2007)		0.71	0.76
Site C (2008)			0.80

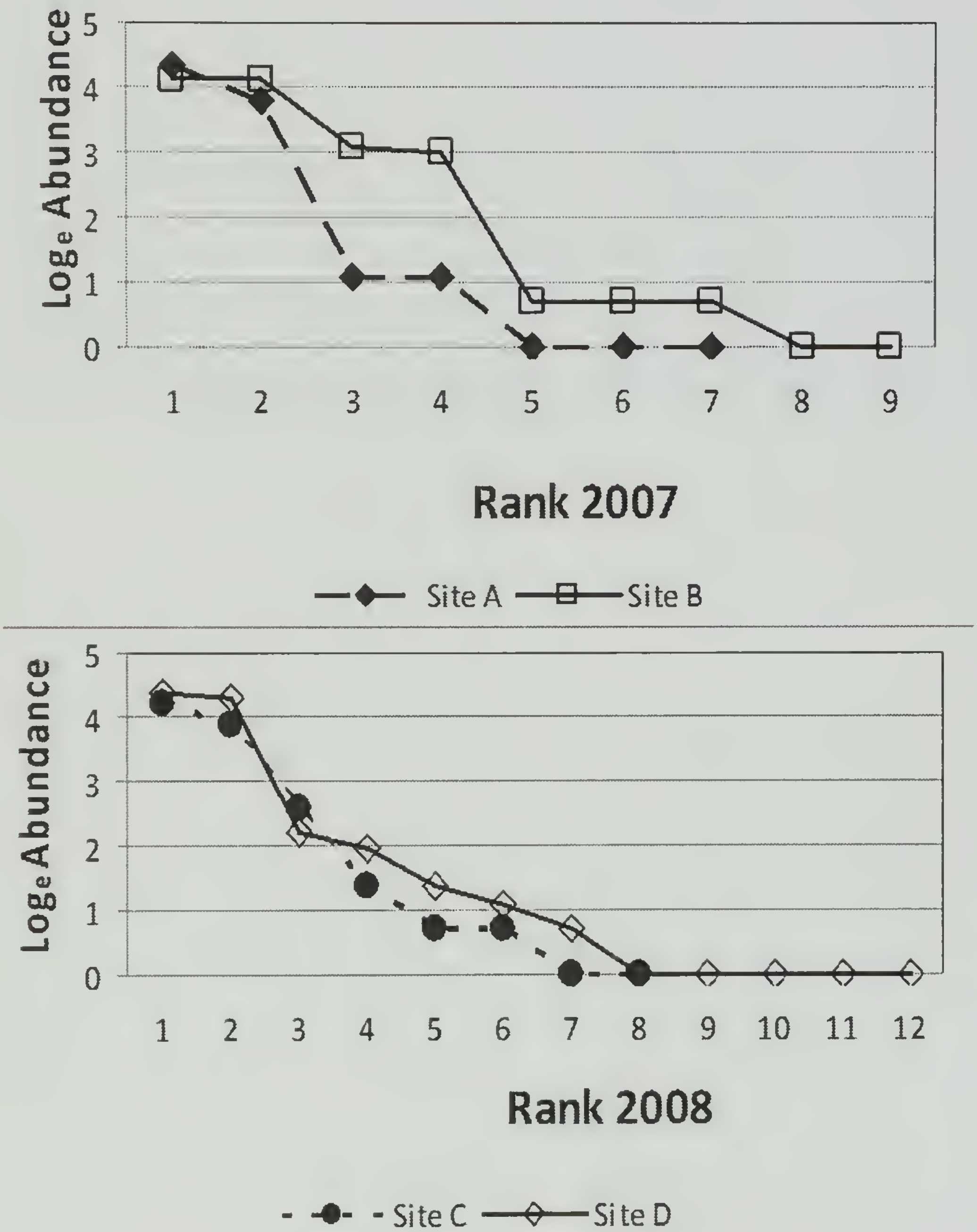

Figure 3. Rank abundance curves for the carabid beetles collected in Stanley Park in 2007 and 2008.

their roles and to more clearly understand the processes that are presumed to be disrupted by forest management activities. Work et al. (2008) have evaluated carabid beetles as indicators of forest change in Canadian boreal forests east of the Rocky Mountains. Unfortunately only 5 of the 93 species they ranked were found in this study and then only as minor species. The carabid fauna in BC is quite distinct and needs further detailed investigation.

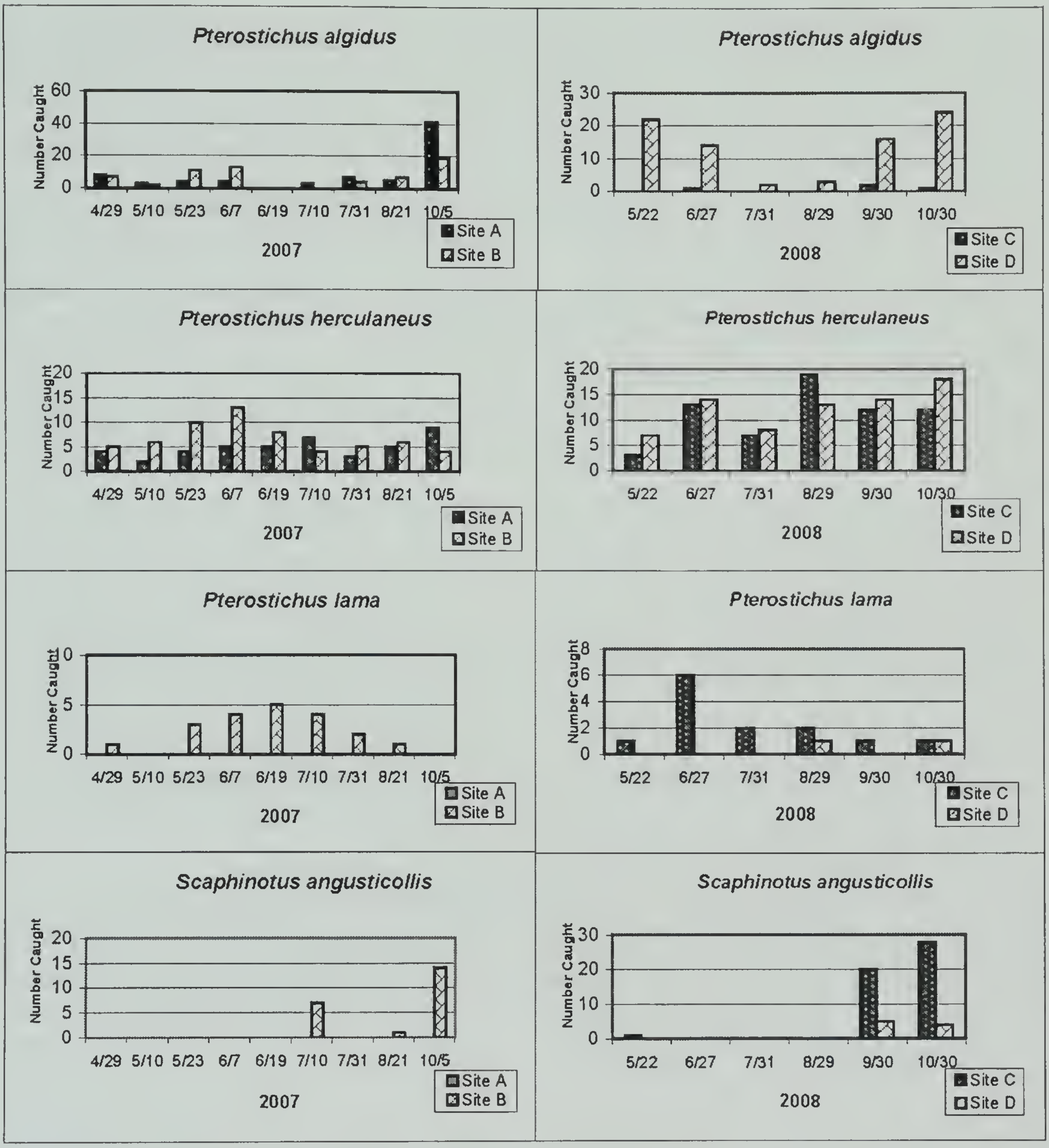

Figure 4. Seasonal abundance of the four most abundant species of ground beetles during 2007 and 2008. Numbers shown represent the total catches from 5 traps in 2007 and 6 traps in 2008.

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Delayed recognition of the European poplar shoot borer, *Gypsonoma aceriana* (Duponchel) (Lepidoptera: Tortricidae), in Canada

LELAND M. HUMBLE[1,2], JEREMY R. DEWAARD[2,3] and MEGHAN QUINN[1,4]

ABSTRACT

The long-term presence of *Gypsonoma aceriana* (Duponchel) (Lepidoptera: Tortricidae: Olethreutinae), a European shoot-boring pest of poplars, was discovered in British Columbia during examination of cytochrome c oxidase I sequences of voucher specimens deposited in the Canadian Forest Service, Pacific Forestry Centre, arthropod reference collection. Originally identified as a species of *Epiblema*, *G. aceriana* was first recovered in BC in 1980, almost 20 years before it was reported in Washington State. DNA barcodes from both larval and adult collections are demonstrated to be conspecific with an adult collection from Great Britain. Preliminary surveys of early and late instar larval feeding damage in southwestern British Columbia demonstrate that this shoot borer is established on southern Vancouver Island and throughout the lower mainland of the province. The eastern-most collections made to date include locations near Yale in the Fraser Canyon, from the lower Coquihalla River watershed and from Hope.

Key Words: *Gypsonoma aceriana*, European poplar shoot borer, *Populus* spp., DNA barcoding, COI, nonindigenous species detection

INTRODUCTION

Two species of shoot-boring *Gypsonoma* (Tortricidae: Olethreutinae) that attack cottonwoods are known to occur in North America. The native cottonwood twig borer (CTB), *G. haimbachii* (Kearfott), ranges across eastern North America (Morris 1967; Solomon 1995), while the introduced European poplar shoot borer (EPSB), *G. aceriana* (Duponchel) (Fig. 1) has been reported only from western Washington State (Miller and LaGasa 2001; LaGasa *et al.* 2001). Both species exhibit similar life histories and damage in cottonwoods. Early instar larvae feed as leaf miners from late summer through fall. The second instar larvae of both species then spin hibernacula on the bark of stems or branches and overwinter. In the spring, larvae emerge from the hibernacula and bore into the developing green shoots, producing silk tunnels covered with frass and debris deposits at the entrances to their feeding galleries. At maturity, larvae of both species leave the damaged shoots and pupate in the leaf litter (Morris 1967; Solomon 1995; Miller and LaGasa 2001; LaGasa *et al.* 2001).

As frass and silk tubes similar to those caused by late instar EPSB and CTB had previously been noted on *Populus* species in British Columbia (BC), we undertook to determine: 1) which of the species of *Gyp-*

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Figure 1. Adult male (dorsal view) of *Gypsonoma aceriana* (Duponchel).

sonoma was present in BC; and, if either was present, 2) the host and geographic ranges of shoot-boring *Gypsonoma* spp. in the southwestern area of the province.

MATERIALS AND METHODS

Larval Rearings. During the spring of 2007, lateral and terminal new growth of black cottonwood, *Populus balsamifera* L. ssp. *trichocarpa* (Torr. & Gray ex Hook.) Brayshaw, and Lombardy poplar, *Populus nigra* L. *cv. 'italica'*, exhibiting feeding damage characteristic of EPSB were collected in the Greater Victoria area (Table 1) and reared until mature larvae emerged and dropped to the bottoms of the rearing tubes. Mature larvae were collected and placed into clean tubes with a 2-cm-deep layer of lightly moistened peat moss and held at room temperature until adult emergence.

Field Collections. In the fall of 2007, a roadside survey of *Populus* species was conducted in southwestern BC, along Highway (Hwy) 3 between Hope and Keremeos, along Hwy 3b from Keremeos to the junction of Hwy 97, along Hwy 97 north to Vernon, then west on Hwy 97 through Falkland to the junction of Hwy 1, and then west on Hwy 1 to Hope. Two branches were cut from all sampled roadside trees (to a maximum of five trees per location), and the undersides of all leaves were examined for leaf mines constructed by first or second instar larvae. A more detailed survey was conducted of the native and hybrid poplars managed by the British Columbia Ministry of Forests and Range at Kalamalka Research Station, Vernon, BC. All leaf mines were dissected, and any larvae recovered were preserved in 95% ethanol. Between 2007 and 2009, additional sites were surveyed for characteristic larval damage of *Gypsonoma* during other field activities. Locations of all sites positive or negative for damage or life stages of *Gypsonoma* are documented in Table 1 (positive collections) or Figure 2 (positive and negative sites).

Historical Collections. Voucher collections and historical records of the Forest Insect and Disease Survey held in the Canadian Forest Service (CFS) Reference collection (PFCA) at the Pacific Forestry Centre (PFC), Victoria, BC, were examined for previous collections of *Gypsonoma*.

Molecular and Morphological Identifications. DNA was extracted from legs removed from pinned adult specimens of *Gypsonoma* or from preserved first or second instar larvae extracted from leaf mines

Table 1.
Collection data for voucher specimens of *Gypsonoma aceriana* (Duponchel) deposited in the reference collection (PFCA) at Natural Resources Canada, Canadian Forest Service, Victoria, British Columbia.

Field Collection Number	Life Stage [No of specimens]	Collection Location	Latitude (dec. deg.)	Longitude (dec. deg.)	Collection Date [Date of adult emergence]	Host & Collection Data	Collector
FIDS 80-0271-01[1]	A	Saanich, Pacific Forestry Centre	48.460	-123.396	11-vi-1980	ex larva from new shoot *P. b. trichocarpa*	R. Duncan
FIDS 81-0384-01[1,2]	L [3]	Saanich, Royal Oak	48.475	-123.406	4-vii-1981	larva from new shoot *P. b. trichocarpa*	Duncan, Dobbin & Burnside
FIDS 81-0384-01[1]	A [3]	Saanich, Royal Oak	48.475	-123.406	4-vii-1981	ex larva from new shoot *P. b. trichocarpa*	Duncan, Dobbin & Burnside
DUN-06-0043-01[1]	A [8]	Saanich, Jolly Place	48.466	-123.383	26-v-2006	ex larva in new shoots, *P. b. trichocarpa*	R. Duncan
PFC-2006-0505	A [1]	Saanich, Pacific Forestry Centre	48.459	-123.397	17-vii-2006	MV light	L. Mavin & M. Young
PFC-2006-0907	A [1]	Saanich, Prospect Lake, Echo Dr.	48.461	-123.397	17-vii-2006	MV light	L. Mavin & M. Young
PFC-2006-1970	A [1]	Saanich, Pacific Forestry Centre	48.461	-123.397	24-viii-2006	MV light	L. Mavin & M. Young
PFC-2006-1971	A [1]	Saanich, Pacific Forestry Centre	48.515	-123.435	20-vii-2006	MV light	L. Mavin & M. Young
HUM-07-0136	L [1]	Saanich, Blenkinsop & Mackenzie	48.473	-123.351	14-vi-2007	larva from new shoot, *P. b. trichocarpa*	L.M. Humble
HUM-07-0136	A [1]	Saanich, Blenkinsop & Mackenzie	48.473	-123.351	[2-vii-2007]	ex larva from new shoot, *P. b. trichocarpa*	L.M. Humble
HUM-07-0144	A [3]	Saanich, Dupplin Rd	48.448	-123.378	[4-viii-2007]	ex larva in shoot *P. nigra cv. 'Italica'*	L.M. Humble
HUM-07-0361	L [20]	Saanich, Pacific Forestry Centre	48.459	-123.397	26-viii-2007	in mine along leaf midvein, *P. b. trichocarpa*	L.M. Humble

Table 1. (continued)

Field Collection Number	Life Stage [No of specimens]	Collection Location	Latitude (dec. deg.)	Longitude (dec. deg.)	Collection Date [Date of adult emergence]	Host & Collection Data	Collector
HUM-07-0362	L [10]	Saanich, Dupplin Rd	48.448	-123.378	26-viii-2007	in mine along leaf midvein, *P. nigra cv. 'italica'*	L.M. Humble
HUM-07-0374	L [65]	Saanich, U of Victoria	48.467	-123.318	5-ix-2007	in mines in leaf *P. b. trichocarpa*	L.M. Humble
HUM-07-0379	L [14]	Saanich, U of Victoria	48.467	-123.318	11-ix-2007	in mines in leaf *P. b. trichocarpa*	M. Bland
HUM-07-0382	L [50]	Saanich, U of Victoria	48.467	-123.318	18-ix-2007	mines on underside of leaf *P. b. trichocarpa*	M. Bland
HUM-07-0383	L [6]	Harrison Mills, N of Mill & Kilby Rds	49.236	-121.940	15-ix-2007	*Populus* hybrid: mines, underside of leaf	M. Bland
HUM-07-0384	L [2]	Hope, Memorial Park	49.381	-121.442	13-ix-2007	mines on underside of leaf, *P. nigra cv. 'italica'*	M. Bland
HUM-07-0385	L [1]	6 km S of Yale	49.516	-121.420	15-ix-2007	mines in leaf of *Populus* sp	M. Bland
HUM-08-0260	L [10]	Saanich, Pacific Forestry Centre	48.459	-123.397	12-v-2008	mining base of leaf petiole *P. b. trichocarpa*	L.M. Humble
HUM-09-0119	L [5]	Nanaimo Lakes Road	49.076	-123.884	29-v-2009	stem mine *P. b. trichocarpa*	L.M. Humble
HUM-09-0120	L [2]	Ladysmith	49.076	-123.967	29-v-2009	stem mine *P. b. trichocarpa*	L.M. Humble
HUM-09-0121	L [14]	Cowichan Bay	48.763	-123.644	29-v-2009	stem mine *P. alba*	L.M. Humble
HUM-09-0122	L [2]	Shawnigan Lake	48.614	-123.627	29-v-2009	stem mine *P. b. trichocarpa*	L.M. Humble
HUM-09-0123	L [8]	Cowichan Bay Road	48.743	-123.632	29-v-2009	stem mine *P. nigra cv. 'Italica'*	L.M. Humble
HUM-09-0124	L [4]	Othello Rd & Coquihalla Hwy	49.385	-121.319	1-vi-2009	stem mine *P. b. trichocarpa*	L.M. Humble
HUM-09-0365	L [2]	Carolin Mines Rd & Coquihalla Hwy	49.481	-121.252	18-vi-2009	mining new shoot *P. b. trichocarpa*	Humble & Noseworthy

[1] Previously identified as *Epiblema* n. sp.
[2] Freeze-dried larvae pinned with damaged shoots exhibiting frass-covered silken tubes

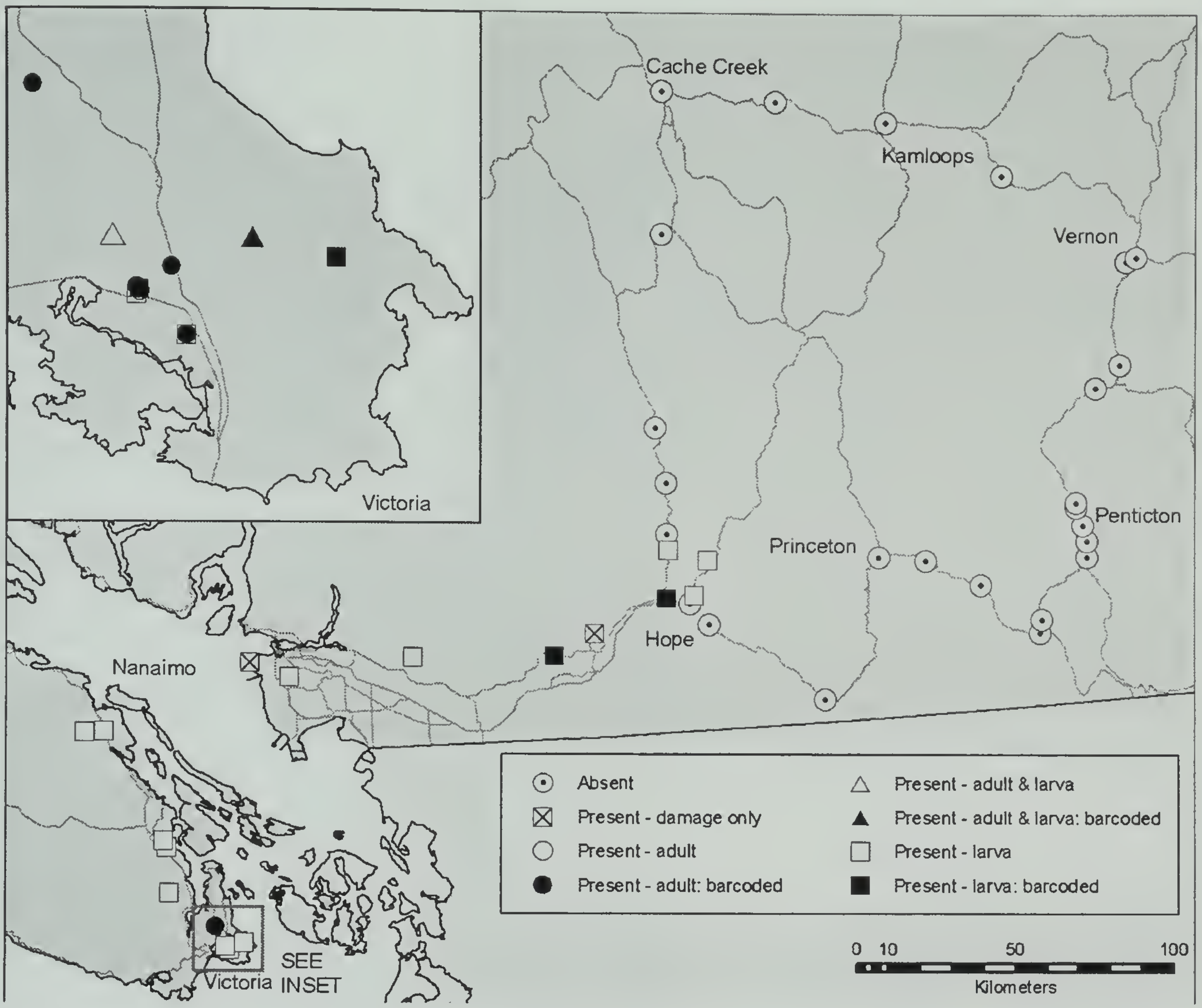

Figure 2. Locations surveyed and distribution of *Gypsonoma aceriana* (Duponchel) in southwestern British Columbia.

on *Populus* spp. (Table 1), and the barcode region of the mitochondrial gene cytochrome *c* oxidase I (COI) was amplified and sequenced using established protocols (Hajibabaei *et al.* 2005; Hebert *et al.* 2004; Ivanova *et al.* 2006; deWaard *et al.* 2008). BOLD-IDS, the identification engine of the Barcode of Life Database [see http://www.barcodinglife.org/views/idrequest.php], was used to assign tentative identifications for all sequences. Identifications were considered definitive if similarity scores of 100% were obtained. The barcode-assigned determinations of adults were confirmed morphologically through genitalic dissections. All specimens were deposited in the collection at the PFC, CFS, Victoria, BC (PFCA).

RESULTS AND DISCUSSION

The locations and hosts of all larval and adult collections of *Gypsonoma* examined in this study are documented in Table 1. We reared four adult *Gypsonoma* from two larval collections on *Populus* species in the Greater Victoria area. COI barcode sequences were obtained from four reared adults and 19 larvae recovered from various *Populus* species in collections made between 2006 and 2008. With the exception of one larva recovered from a leaf mine on black cottonwood in Victoria, all individuals collected were assigned to the species *Gypsonoma aceriana* (Duponchel) (Fig. 3) by the BOLD-IDS engine. A single larva of *Batrachedra praeangusta* (Haworth) recovered from an EPSB mine in the base of a leaf petiole in the spring of 2008 was also

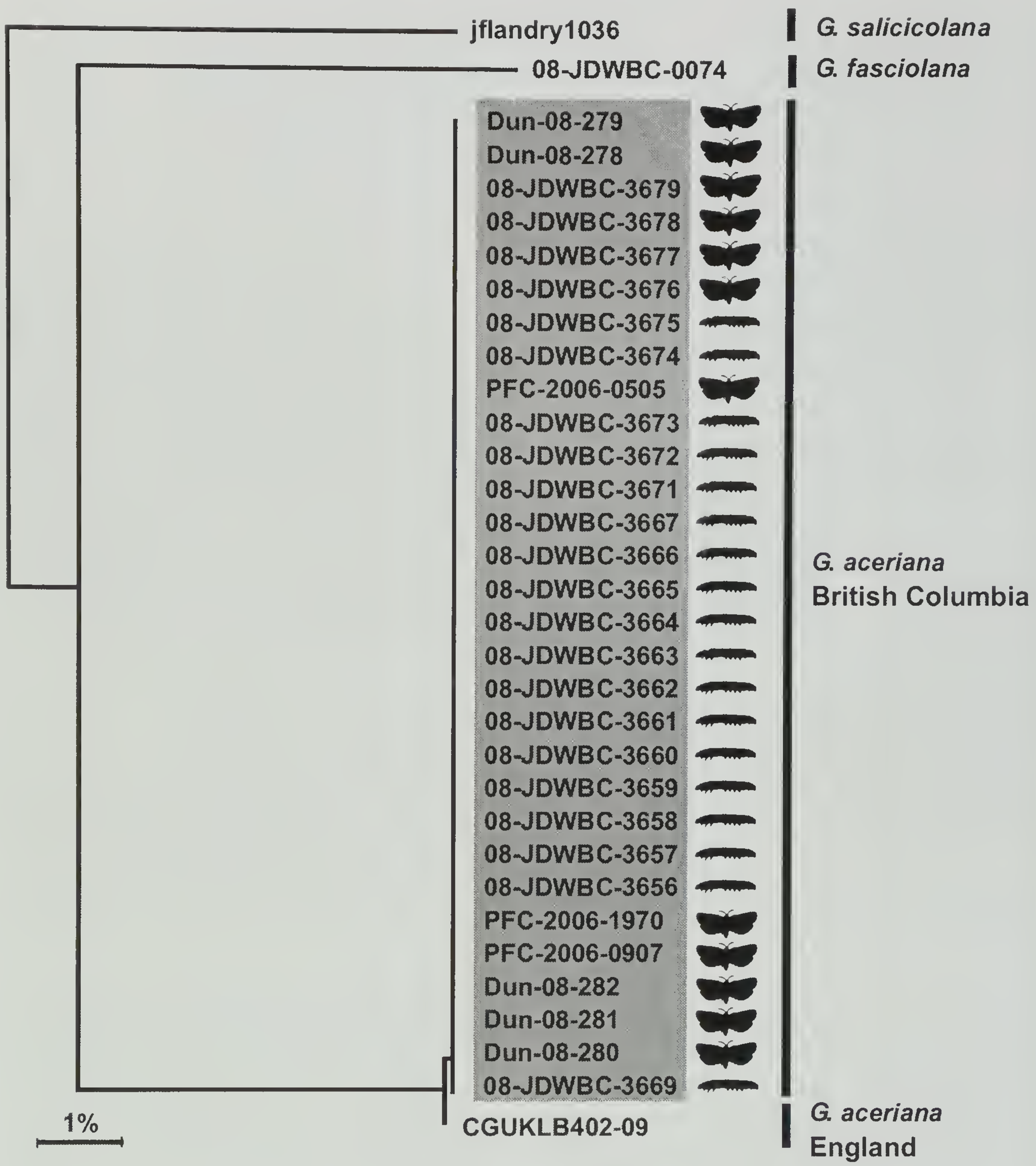

Figure 3. Taxon-ID tree of *Gypsonoma aceriana* (Duponchel) and congeners in British Columbia (modified from the tree output option of the Barcode of Life Database Identification System).

identified with BOLD-IDS. The neighbour-joining tree (based on Kimura-2-parameter distances (Kimura 1980) of COI sequences) that was generated by the BOLD-IDS engine also identified an additional nine COI sequences from voucher specimens deposited in PFCA (barcoded by LMH in order to build reference libraries of COI sequences) as those of *G. aceriana*. Five of the sequences were derived from moths originally identified as *Epiblema* sp. that had been reared from late instar larvae on *P. b. trichocarpa* in 2006, and an additional four sequences were obtained from moths captured in light traps on southern Vancouver Island in 2007 (Table 1). BOLD-IDS indicated a close match between the specimens barcoded from BC (Table 2) and a single

reference specimen from Great Britain (Fig. 3). Genitalic dissection of FIDS 80-0271-01 confirmed the identification of the adult moths as *G. aceriana*.

A re-examination of the Olethreutinae housed in PFCA led to the discovery of three additional pinned adults and three freeze-dried larvae pinned in association with damaged shoots bearing the frass-covered entrance tubes characteristic of EPSB. The adults had been submitted to the Canadian National Collection in Ottawa in 1981 (Lot. No. 81-42) for determination and were identified as "probably *Epiblema* sp.". That report noted that individuals of the other sex (males) were required for a definitive identification. A search of the historical Forest Insect and Disease Survey records (1949–1995) for all collections identified as *Epiblema* sp. on *Populus* species in BC produced five records, including the 1980 and 1981 collections (FIDS 1980-0271-01 and 1981-0384-01) that were confirmed to be *G. aceriana* in this study. No voucher specimens could be located for the remaining three collections; however, a series of damage photographs from one collection from the Cariboo (FIDS 1992-9-0083-01, Horse Lake, BC, 51.607°, -121.205°, 2-vi-1992, 6 larvae, D. White) document larvae identified as *Epiblema* boring in new shoots of *P.b. trichocarpa*. The absence of a dark prothoracic shield (present in *G. aceriana*) in the larval images from Horse Lake provides conclusive evidence that the damage was not caused by EPSB. Damage similar to that noted at Horse Lake was collected again in 1994 (FIDS 1994-9-0668-01, Blue Lead Cr, E end of Quesnel Lake, 52.625°, -120.375°, 23-vi-1994, *P. b. trichocarpa,* damage only, R. Erickson). As this collection is in close proximity to the previous collection, we suggest that it is unlikely to have been caused by EPSB. The final record (FIDS 1991-9-0718-01, Saanichton, CPFP Seed Orchard, 30-v-1991, 48.600°, -123.440°, damaged shoots of *Populus* sp.) also consisted of damage only, and thus cannot be conclusively attributed to EPSB.

The occurrence of *G. aceriana* in North America was first reported by Miller and LaGasa (2001) after a single male of EPSB was recovered near the port area of Seattle, WA, in 1998 and single males were detected at two additional locations in 1999. Subsequent surveys by LaGasa *et al.* (2001) demonstrated that EPSB was widely distributed in western Washington State. Voucher specimens (adults and freeze-dried larvae with associated damage) misidentified as *Epiblema* sp. (Tortricidae: Olethreutinae) deposited in PFCA demonstrate that EPSB was already present in southwestern BC by 1980, almost 20 years before the species was first recorded in Washington State.

As all but one late instar larvae recovered from mines in petioles and new shoots in the spring, as well as all early instar larvae recovered from mines on the underside of leaves in the fall, exhibited COI sequences identical to those of reared adults of *G. aceriana*, we feel confident that our visual survey records can be used to develop the first map of occurrences of EPSB in BC (Fig. 2). The full extent of ESPB distribution is yet unknown. It has been recovered on southeastern Vancouver Island from Victoria to Nanaimo, throughout the Fraser River valley, and as far inland as Yale in the Fraser Canyon and Carolin Mines Road along the Coquihalla Highway (Fig. 2). To date, evidence of damage caused by *Gypsonoma* sp. has not been found east of these locations. Although it is possible that low-level populations of EPSB may be present at some sites examined in the fall 2007 survey, we feel that the initial data are representative of EPSB distribution in those areas surveyed, as there was also no evidence of the more conspicuous debris-covered silken tubes constructed by the later instar larvae at the entrance to larval feeding tunnels that persist into the fall and winter (LaGasa *et al.* 2001). The results of this survey could be confirmed using pheromones identified by Booij and Voerman (1984).

Miller and LaGasa (2001) note that similarities between the poplar floras of Europe and North America, as well as the wide distribution of EPSB and its status as

Table 2.

Field collection numbers, Barcode of Life Database Sample ID and Process ID registration numbers, GenBank accession numbers, and life stage sampled for COI sequences of all individuals successfully barcoded. Unless otherwise noted, all barcoded specimens are *Gypsonoma aceriana*. Voucher specimens are deposited in the reference collection (PFCA) at Natural Resources Canada, Canadian Forest Service, Victoria, British Columbia.

Field Collection Number	BOLD Sample ID	BOLD Process ID	GenBank Accession No.	Life Stage
DUN-06-0043-01	Dun-08-278	DUNLP278-08	GQ845373	adult
DUN-06-0043-01	Dun-08-279	DUNLP279-08	GQ845374	adult
DUN-06-0043-01	Dun-08-280	DUNLP280-08	GQ845375	adult
DUN-06-0043-01	Dun-08-281	DUNLP281-08	GQ845376	adult
DUN-06-0043-01	Dun-08-282	DUNLP282-08	GQ845377	adult
HUM-07-0382	08-JDWBC-3656	LBCG3656-09	GQ845378	larva
HUM-07-0382	08-JDWBC-3657	LBCG3657-09	GQ845379	larva
HUM-07-0382	08-JDWBC-3658	LBCG3658-09	GQ845380	larva
HUM-07-0382	08-JDWBC-3659	LBCG3659-09	GQ845381	larva
HUM-07-0382	08-JDWBC-3660	LBCG3660-09	GQ845382	larva
HUM-07-0382	08-JDWBC-3661	LBCG3661-09	GQ845383	larva
HUM-07-0382	08-JDWBC-3662	LBCG3662-09	GQ845384	larva
HUM-07-0382	08-JDWBC-3663	LBCG3663-09	GQ845385	larva
HUM-07-0382	08-JDWBC-3664	LBCG3664-09	GQ845386	larva
HUM-07-0382	08-JDWBC-3665	LBCG3665-09	GQ845387	larva
HUM-07-0382	08-JDWBC-3666	LBCG3666-09	GQ845388	larva
HUM-07-0382	08-JDWBC-3667	LBCG3667-09	GQ845389	larva
HUM-07-0384	08-JDWBC-3672	LBCG3672-09	GQ845390	larva
HUM-07-0383	08-JDWBC-3673	LBCG3673-09	GQ845391	larva
HUM-07-0383	08-JDWBC-3674	LBCG3674-09	GQ845392	larva
HUM-07-0383	08-JDWBC-3675	LBCG3675-09	GQ845393	larva
HUM-08-0260	08-JDWBC-3669	LBCG3669-09	GQ845394	larva
HUM-08-0260	08-JDWBC-3671	LBCG3671-09	GQ845395	larva
HUM-07-0136	08-JDWBC-3676	LBCG3676-09	GQ845397	adult
HUM-07-0144-A	08-JDWBC-3677	LBCG3677-09	GQ845398	adult
HUM-07-0144-B	08-JDWBC-3678	LBCG3678-09	GQ845399	adult
HUM-07-0144-D	08-JDWBC-3679	LBCG3679-09	GQ845400	adult
PFC-2006-0505	PFC-2006-0505	LPVIA333-08	GQ845401	adult
PFC-2006-0907	PFC-2006-0907	LPVIA665-08	GQ845402	adult
PFC-2006-1970	PFC-2006-1970	LPVIB549-08	GQ845403	adult
PFC-2006-1971	PFC-2006-1971	LPVIB550-08	GQ845404	adult
HUM-08-0260	08-JDWBC-3670	LBCG3670-09	GQ845396	larva[1]

[1] Larva of *Batrachedra praeangusta* (Lepidoptera: Momphidae) recovered from frass and debris covered silk tunnel at the base of a leaf petiole

a pest in Europe, suggest that this shoot-borer could still become a significant pest of poplars in North America. Because of its lengthy presence in western North America, the pathway by which EPSB was introduced will never be determined. In BC, *G. aceriana* has been recorded from native black cottonwood, as well as two introduced poplars, European white poplar (*Populus alba* L.) and Lombardy poplar, that are widely planted as ornamentals or windbreaks in southwestern BC. The detection of EPSB in native poplars beyond urban forests (see Table 1, collection HUM-09-0365) suggests that natural spread has already occurred. The impact of EPSB on native poplars has not been evaluated in North America; however, in Belgium, Heymans *et al.* (1983) found that clones of *P. trichocarpa* and *P. trichocarpa* X *deltoides* hybrids were more susceptible to EPSB damage than were *P. deltoides* X *nigra* clones, with the earliest flushing clones sustaining the heaviest damage. The cryptic nature of the hibernacula of overwintering second instar larvae makes detection of this pest in horticultural or forest nursery stock very difficult. Prevention of continued spread of EPSB through movement of live plants or planting stock will require concerted efforts of the horticultural and forest silvicultural sectors.

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Distribution of attacks and egg galleries by the spruce beetle around the bole of windthrown trees

L. SAFRANYIK[1]

ABSTRACT

The distribution of attack density and egg gallery length by the spruce beetle around the bole of windthrown spruce trees was investigated in central British Columbia. In windthrown trees that are oriented north–south or east–west, the circular distributions of both attack density and egg gallery length were significantly different from the uniform distribution. The mean directions for the center of mass of the distributions suggest an evolved preference by the spruce beetle for establishing broods relative to habitat quality. The preferred habitats for brood establishment were the shaded bottoms and lower sides of windthrown trees. This finding is consistent with the hypothesis that attack preference is a function of solar insulation during the attack period.

Key Words: Spruce beetle, attacks, circular distribution, survival, sampling

INTRODUCTION

The spruce beetle, *Dendroctonus rufipennis* (Kirby) (Coleoptera: Curculionidae, Scolytinae), is native to spruce (*Picea sp.*) forests of North America (Bright 1976). Endemic spruce beetle populations breed in fresh windthrown trees, logging residue, injured, diseased or decadent trees. Spruce windthrow is common in mature spruce forests and is the preferred host material of the spruce beetle even during outbreaks (Schmid 1981).

Windthrown trees, especially those that are scattered in stand interiors provide superior breeding habitat for the spruce beetle over standing trees likely because of attributes such as snow cover that protects the broods from extremely cold temperatures and from predation by woodpeckers. Windthrow occurs more frequently in the larger-diameter classes and may also offer better nutritional conditions for brood survival compared to standing trees with low vigour.

Dyer and Taylor (1971) reported higher brood survival by the spruce beetle on the bottom of windthrown trees compared to the upper sides and Schmid (1981) found differences in both attack density and brood densities among the tops, sides and bottoms of windthrown trees. My objective was to test the null hypothesis that the circular distribution of attack densities and egg gallery lengths/m^2 around the bole circumference of spruce windthrow is uniform and independent of the direction of fall. I have quantified the circular distributions and provided an explanation in terms of the adaptive and practical significance of the results.

MATERIALS AND METHODS

The study site was located approximately 75 km southeast of Prince George, British Columbia, in the Naver Creek watershed (53°24' N; 122°20' W), at an elevation range of 900 m to 1400 m. The stands comprised mature (> 150 years) hybrid white spruce (*P. glauca* x *P. engelmanni* hybrid population) and subalpine fir [*Abies lasiocarpa* (Hook) Nutt.], with an average stand density of 171 stems per hectare

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greater than 20 cm diameter at breast height (dbh). Spruce dominated the overstorey, making up 73.1 % of the stems greater than 20 cm dbh, with an average diameter at 1.3 m (dbh) of 50.5 cm. A few mature Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco], lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.), white birch (*Betula papyrifera* Marsh.), and aspen (*Populus tremuloides* Michx.) were scattered throughout the study areas.

The windthrown trees used in the study were located in stand interiors and were attacked by spruce beetle during the spring of 1974. The following spring, bolts cut from six and five separate windthrown trees, oriented north–south (N-S) and east–west (E-W), respectively, were sampled to determine the circular distribution of spruce beetle attacks and egg gallery lengths around the bole. Prior to cutting, the top of each bolt was determined and marked as the midpoint between vertical posts positioned next to the bole on opposite sides.

From each selected N-S tree, one bolt averaging 42.1 cm in length (range: 29.6 cm to 51.8 cm) was cut from each of the bottom, middle and top third of the infested bole. The average diameter of the bolts was 33.8 cm (range: 21.3 cm to 46.6 cm). From the selected E-W trees, 13 bolts were cut, one to four bolts per tree. The average length and average diameter of the bolts were 41.4 cm (range: 28.9 cm to 56.1 cm) and 32.6 cm (range: 26.8 cm to 54.8 cm), respectively. In the laboratory, each end of each bolt circumference was divided into nine equal strips, each strip representing a 40° angular interval. On bolts cut from N-S windthrow, the first such interval was designated as being located directly west of the top of the bolt. On bolts cut from E-W windthrow, the first 40° angular interval was designated as being located directly north of the top of the bolt. Continuing from the top around the circumference of the bolt, each strip was designated by the midpoint of the respective angular interval; e.g., 20°, 60°, ..., 340°.

All bark was carefully removed from each strip, and the following information was recorded:

- strip length and width;
- number of egg gallery entrances (attacks), and;
- length of exposed egg galleries.

Egg gallery length in a bark strip was defined as the sum of the lengths of all complete egg galleries and the lengths of all partial egg galleries. The number of attacks and total egg gallery lengths were converted to numbers per square meter prior to analysis by dividing respective totals by the strip bark area. In what follows, egg gallery length/m^2 is referred to as egg gallery length.

For bolts cut from N-S windthrow, variation in attack density and egg gallery length by tree and bolt position were analysed by analysis of variance in a randomized complete block design with windthrown trees as blocks. For bolts cut from E-W windthrow, variation in attack density and egg gallery length by windthrow was analysed by analysis of variance in a completely randomized design. The relationship between densities of attack and egg gallery length was analysed by linear regression. For bolts cut from N-S windthrow, the empirical circular distributions by bolt position and of the total number of attacks were compared by chi-square test, as were the overall empirical circular distributions of the total number of attacks by windthrow orientation (Batschelet 1965).

The statistics for the empirical circular distributions of attack density and egg gallery length by windthrow orientation were calculated as in Batchelet (1965). Based on the observed angular distribution of attacks and egg gallery lengths, the mean direction (α_m) was calculated as follows:

[1a] $\alpha_m = \arctan\{[(1/n)\ \Sigma^n \sin(\alpha_i)]/[(1/n)\ \Sigma^n \cos(\alpha_i)]\}$, if $(1/n)\ \Sigma^n \cos(\alpha_i) > 0$.

[1b] $\alpha_m = 180° + \arctan\{[(1/n)\ \Sigma^n \sin(\alpha_i)]/[(1/n)\ \Sigma^n \cos(\alpha_i)]\}$, if $(1/n)\ \Sigma^n \cos(\alpha_i) \leq 0$,

where α_i = the angle corresponding to the midpoint of angle class i. The length of the mean vector (r), dispersion about the mean direction in radians (s) and skewness (g) were calculated as given in equation 2, 3 and 4, respectively:

[2] $r = (x^2 + y^2)^{0.5}/n$; $x = \Sigma^n \cos(\alpha_i)$, $y = \Sigma^n \sin(\alpha_i)$, n = sample size.

[3] $s = [2(1-r)]^{0.5}$

[4] $g = r_2 (\sin (2\alpha_m - \alpha_{2m})$, α_{2m} is calculated as in equations [1a] and [1b] and r_2 is calculated as in equation [2] but by doubling each angle α_i

The Rayleigh test (z; Batschelet 1965) was used to test the null hypothesis that the distribution of the direction of fall of windthrown trees was uniform (equation 5).

[5] $z = nr^2$

RESULTS

In N-S windthrow, there was significant variation among windthrow in attack density, but not in egg gallery length or in either of these variables among bolt positions within trees (Table 1). The mean attack density and egg gallery length was 18.3/m^2 and 250.1cm/m^2, respectively. In E-W windthrow, there was no significant variation among trees in attack density or egg gallery length (Table 1). The mean attack density and egg gallery length was 20.9/m^2 and 278.3 cm/m^2, respectively.

The relationship between egg gallery length/m^2 (Y) and attack density/m^2 (X) was linear for both windthrow orientations (Figure 1). The equation for the combined data is given in equation 6.

[6] Y = 21.47 + 12.93 X, n = 135, r = 0.839, s.e. = 145.82

The intercept of [6] was not significantly different from zero (t =1.285, p = 0.20). The estimated average egg gallery length per attack based on the zero intercept regression of Y on X (equation 7) was 13.55 cm.

[7] Y = 13.55 X

Even though there was a strong linear relationship between egg gallery length and attack density, mean egg gallery length per attack tended to be higher in those orientation angle classes that corresponded with the highest mean attack densities (Figure 2).

In N-S windthrow, there was no significant difference in the circular distributions by bolt position of attack totals per strip ($\chi^2_{(12df)} = 12.83$, p = 0.37). Based on this finding, and the observation of no difference in either attack or egg gallery length among bolt positions, and the highly significant correlation among attack density and egg gallery length, analysis of the circular distributions of attack density and egg gallery length was done on data combined over bolt position.

The circular distributions of attack (a) and egg gallery length (e) differed significantly from uniform distributions in bolts cut from windthrow oriented either N-S or E-W (Table 2). The length of the mean vector and the dispersion about the mean direction for each of the variables (a) and (e) were nearly the same magnitude in both windthrow orientations. The mean angles were nearly identical for attack density and egg gallery length within, but not between, the two orientations (Table 2). In N-S windthrow, the mean angles for both variables were greater then the respective means in E-W windthrow. The distribution of egg gallery length was more skewed than that for attack density, especially in N-S windthrow (Table 2).

There was no difference in the empirical circular distributions of attacks per bark strip in windthrow of the two orientations (Table 3). This result is explained by the nerly identical mean vectors and dispersions of attack density in windthrow of the two orientations (Table 2). Because attack density and egg gallery length were highly correlated, the distribution of the latter was largely determined by that of the former. In windthrow, of both orientations, both attack density and egg gallery length were highest on the bottom quadrants of the trees. (Figures 3 and 4). The respective means corresponded with the angular intervals 120° to 160°, 240° to 280° (north–south) and 80° to 120°, 200° to 240° (east–west).

Table 1.
F-statistics and associated probability levels for variation among windthrown spruce trees and among positions in trees of attack density and egg gallery length for windthrow oriented north–south and for variation among windthrow oriented east–west.

Source of variation	Attacks/m^2	Egg gallery length/m^2
	Windthrown trees oriented north–south	
Trees	$F_{4,8\ df} = 4.324$, $p \leq 0.037$	$F_{4,8\ df} = 1.575$, $p \leq 0.270$
Position	$F_{2,8\ df} = 2.139$, $p \leq 0.180$	$F_{2,8\ df} = 0.126$, $p \leq 0.883$
	Windthrown trees oriented east–west	
Trees	$F_{5,7\ df} = 0.609$, $p \leq 0.697$	$F_{5,7\ df} = 2.688$, $p \leq 0.115$

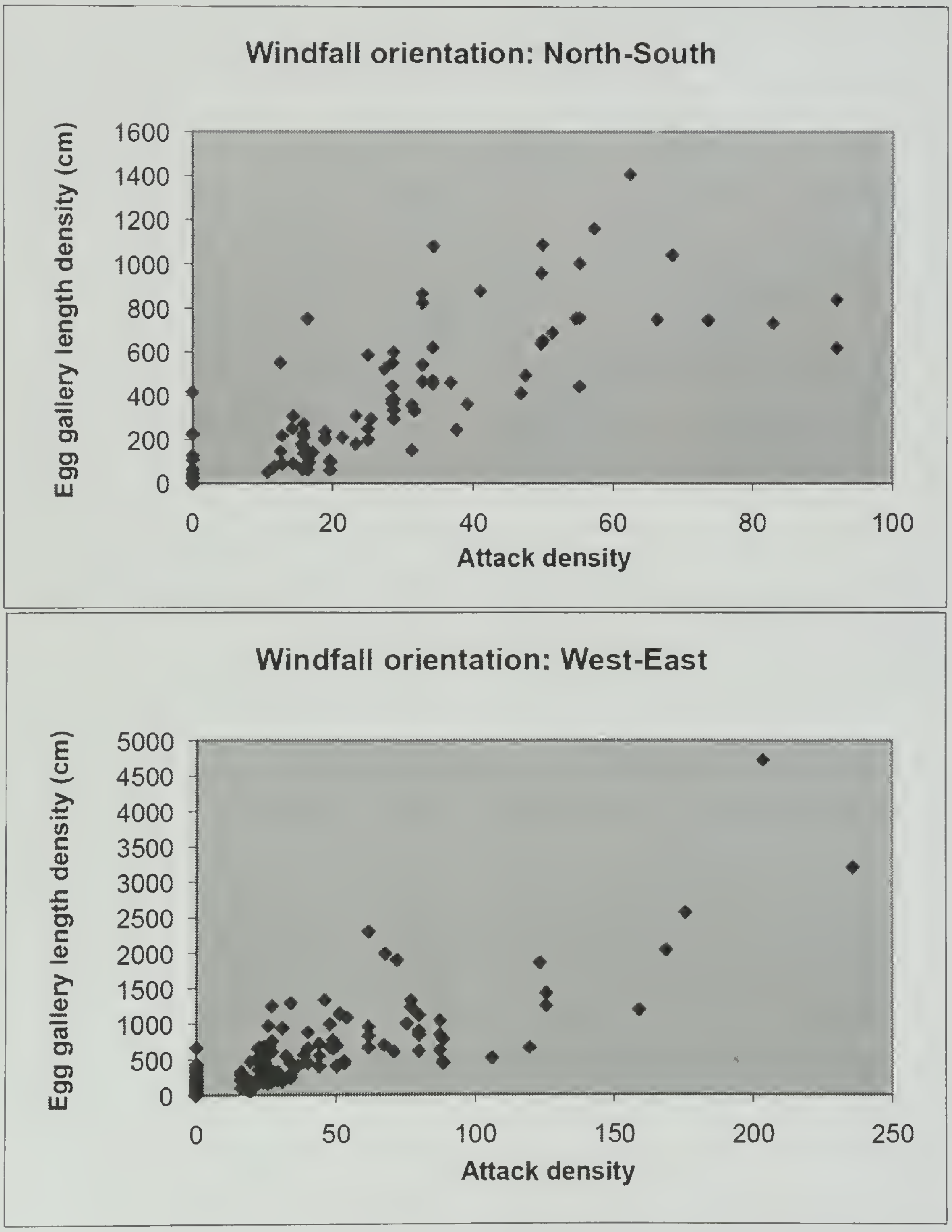

Figure 1. Relationship between egg gallery length (cm)/m^2 and attack density/m^2 by the spruce beetle in spruce windthrow oriented in two directions. Pooled data from all orientation angle classes.

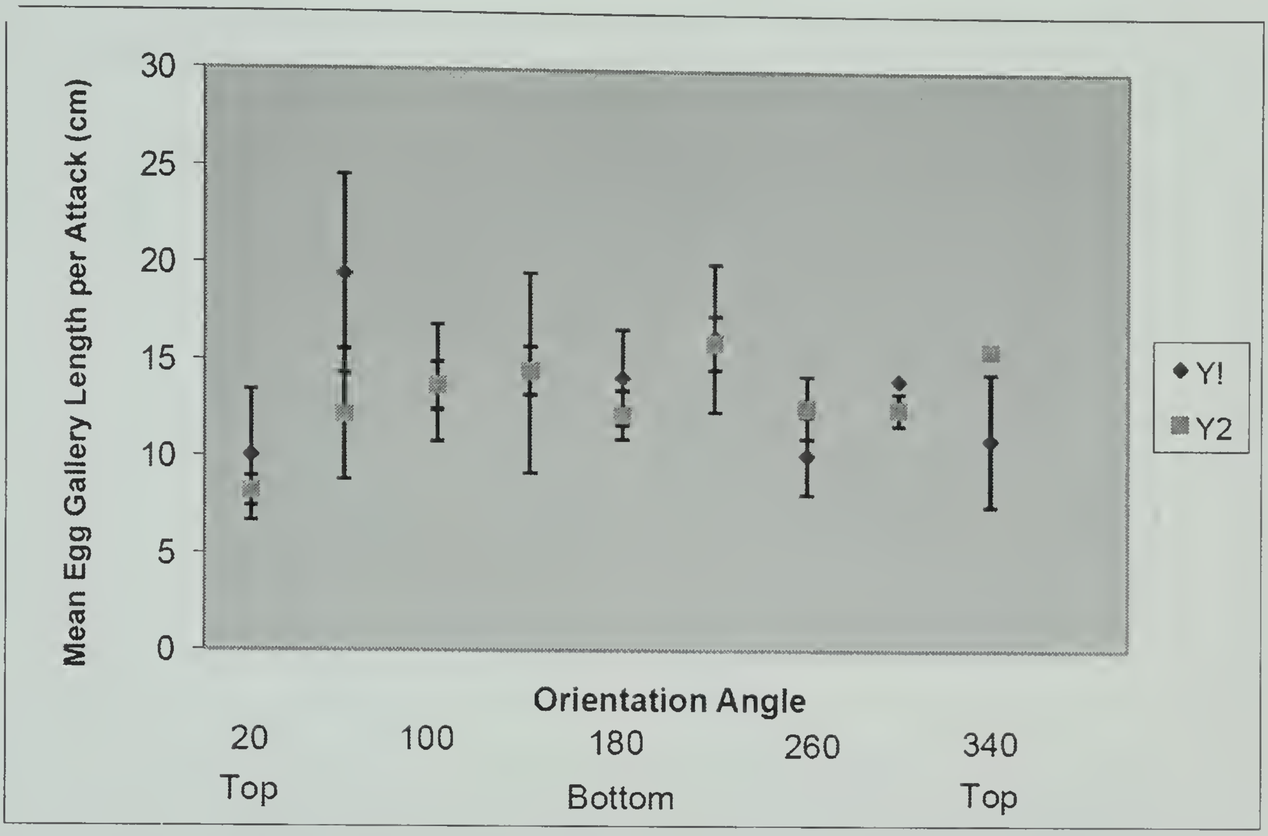

Figure 2. Mean egg gallery length per attack (±1SD) by the spruce beetle in windthrow oriented north–south (Y2) and east–west (Y1) around the circumference of the bole.

Table 2.
Statistics for the empirical distributions of attack density and egg gallery length around the bole in spruce windthrow oriented in two directions.

Statistic[1]	Direction of fall			
	North–South		East–West	
	Attacks/m^2	Egg gallery (cm)/m^2	Attacks/m^2	Egg gallery (cm)/m^2
Mean direction (α_m)	184.9°	182.1°	167.3°	166.4°
Mean vector (r)	0.307	0.350	0.284	0.317
Dispersion (s)	67.5°	65.3°	68.6°	67.0°
Skewness (g)	0.034	0.150	0.085	0.114
$Z=nr^2$	15.268**	27.685**	8.720**	13.767**

[1] See equations 1 to 5 in Methods
** Significant at $p \leq 0.01$

DISCUSSION

Mean attack density, egg gallery length, and mean egg gallery length per attack found in this study are typical for endemic spruce beetle populations in spruce windthrow in central British Columbia. Over a five-year period in the Naver Forest, the yearly mean attack density by spruce beetle in windthrow ranged from 14.7/m^2 to 51.7/m^2, and the corresponding range in egg gallery length was 120cm/m^2 to 670cm/m^2 (Safranyik and Linton 1999). The mean egg gallery length per attack found in this study (13.55 cm) was well within the range reported by Safranyik and Linton (1999; 8.2 cm to 19.8 cm) and close to the average egg gallery length in spruce bolts (12.7 cm; Safranyik and Linton 1983) and trees (13.0 cm; Wood 1982). The lack of significant variation by bolt position in attack density and egg gallery length was surprising, con-

Table 3.
Chi-square test of the empirical distributions around the bole of attacks per bark strip by the spruce beetle in spruce windthrow oriented in two directions.

Angle class mid-point	Observed			Expected	
	North–South	East–West	Sum	North–South	East–West
20 (top)	7	8	15	9.0	6.0
60	11	8	19	11.4	7.6
100	13	16	29	17.4	11.6
140	30	17	47	28.2	18.8
180 (bottom)	28	18	46	27.6	18.4
220	22	19	41	24.6	16.4
260	29	10	39	23.4	15.6
300	11	9	20	12.0	8.0
340 (top)	11	13	14	8.4	5.6
Sum	162	108	270	162	108

$\chi^2_{(8df)} = 10.54$, p=0.23

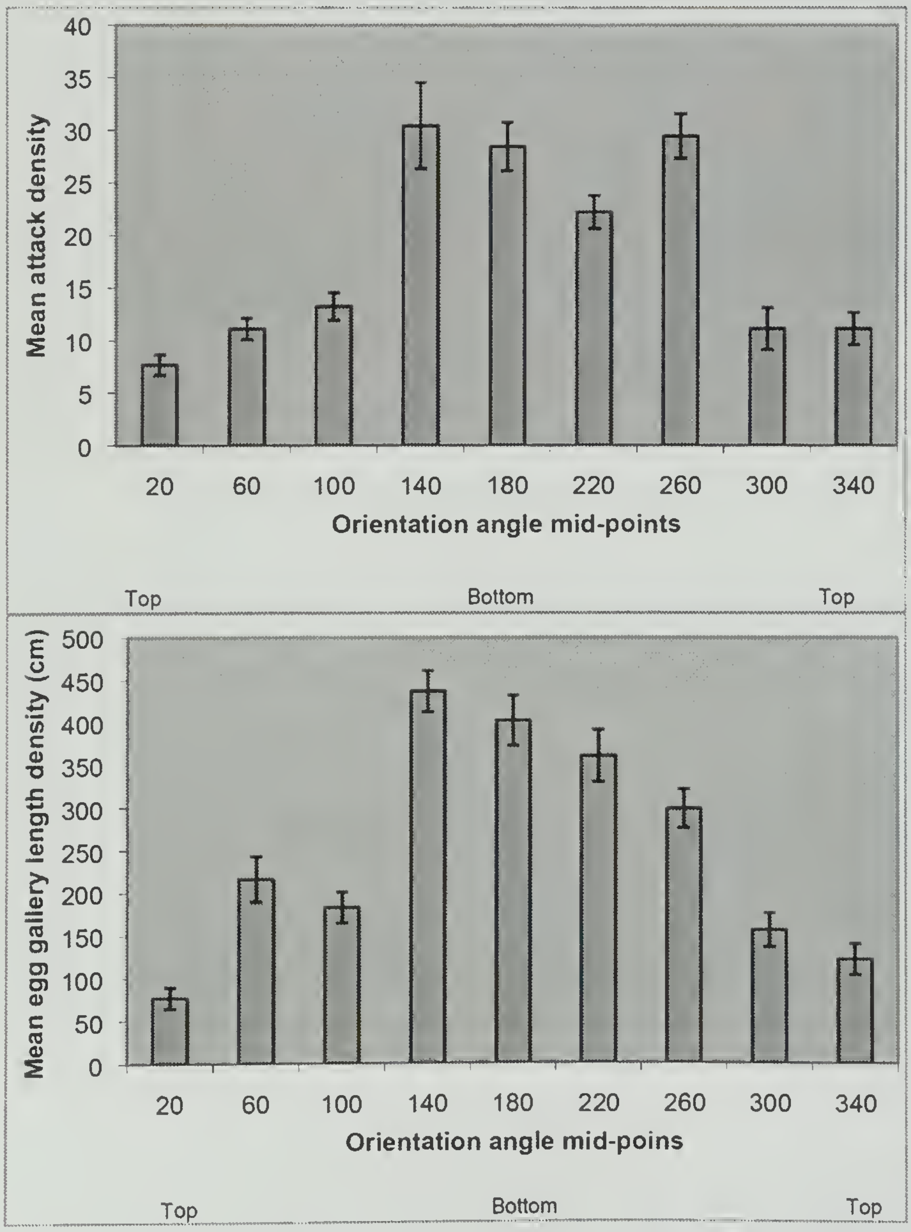

Figure 3. Empirical circular distribution of mean attack density/m2 (±1SE) and egg gallery length/m2 (±1SE) by the spruce beetle on spruce windthrow oriented north–south.

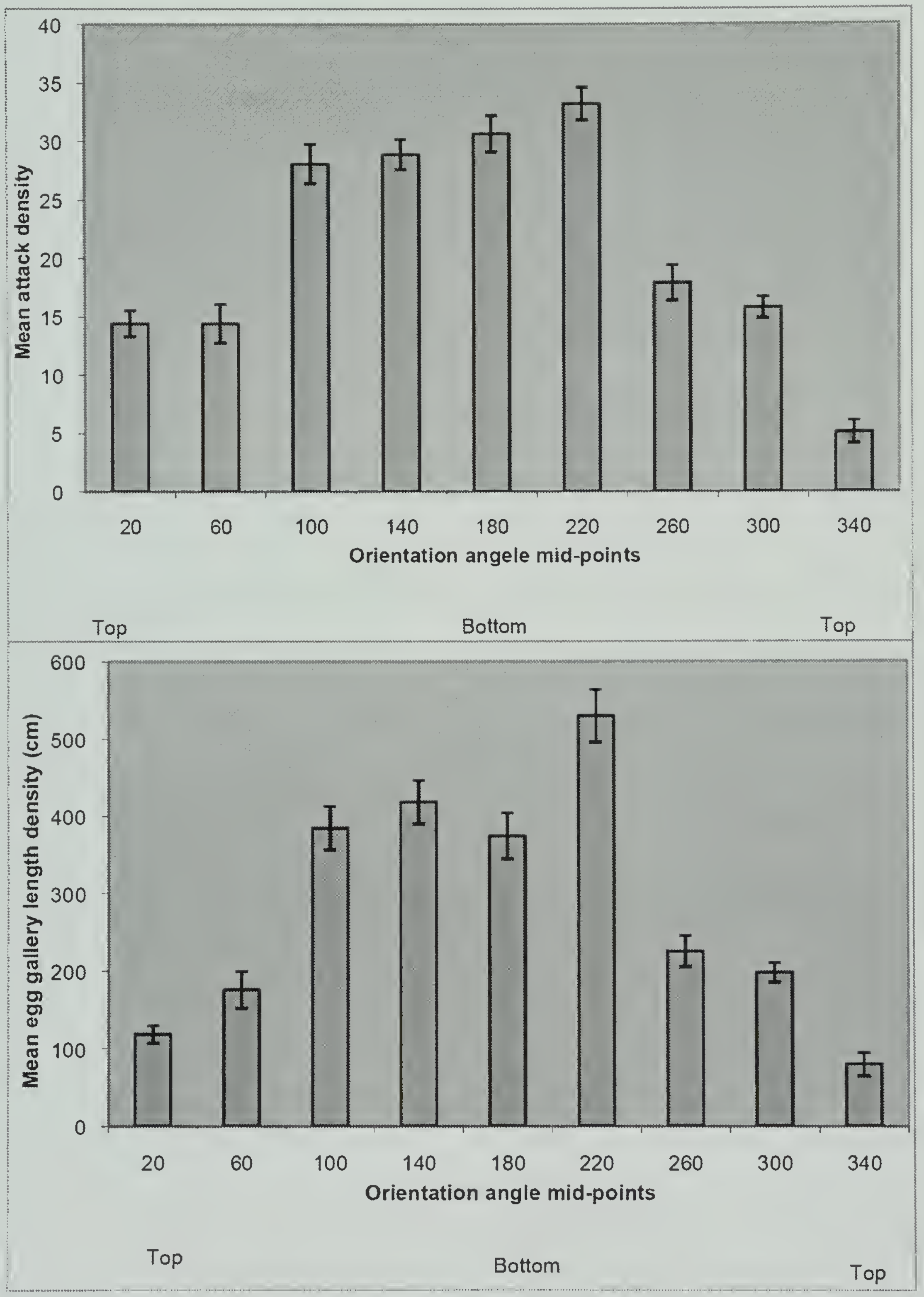

Figure 4. Empirical circular distribution of mean attack density/m^2 (±1SE) and egg gallery length/m^2 (±1SE) by the spruce beetle on spruce windthrow oriented east–west.

sidering changes along the bole in host variables such as diameter, bark thickness branch size and density, and the humped distribution of attacks on height above ground (Safranyik and Linton 1987).

Even though there was a strong linear relationship between attack density and egg gallery length, mean egg gallery length per attack tended to be higher in the orientation-angle class that had the highest attack densities (Figure 2). This suggests that, in addition to attack density, the position of an attack on the bolt circumference affected egg gallery length per attack. This effect explains, in part, the relatively greater skewness of the empirical circular distributions of egg gallery length compared to the attack density (Table 2; Figures 3 and 4).

The results reported in this paper regarding the distribution of attacks around the bole by the spruce beetle in windfall confirm earlier results. Safranyik and Linton

(1987; 1988) reported higher attack densities by the spruce beetle on the north aspects of trees, near the duff, and the shaded (northeast and southeast) aspects of stumps. Schmid (1981) reported that, in windthrow, attack and brood densities were the highest on the bottom, lowest on the top, and intermediate at the sides of the bole. Moreover, Safranyik and Vithayashai (1971) found a significantly non-uniform circumferential distribution of attacks by the mountain pine beetle (*Dendroctonus ponderosae* Hopkins) around the bole of lodgepole pine (*Pinus contorta* Douglas var. *latifolia* Engelmann) with highest attack density corresponding to the shadiest aspect of the bole during the time of peak daily attack period.

The highly significant mean vectors for the circular distribution of attack and egg gallery length in windthrown trees of both orientations indicate an evolved preference for brood establishment based on habitat quality. In both windfall orientations, there was a strong preference by beetles to establish attacks on the bottom of the bole, as indicated by the direction of the mean vector. In N-S and E-W windthrow, the "center of mass" of attacks was located 5° east and 13° north of bottom center of the bole, respectively. Due to the low density of the overstory trees in this study (mean distance among neighbouring trees =7.6 m), most windthrow received only light to moderate shading, resulting in differences in insulation on various aspects of the bole. In N-S and E-W windthrow, excepting the bottom of the bole, respectively the east and north sides would have received the least insulation during peak daily attacks.

In mature spruce forests, most of the endemic windthrow is comprised of larger-diameter trees (Stathers et al. 1994). Windthrown trees have no resistance to attack, and often provide a large and thermally stable phloem resource for exploitation, especially at the bottom and sides of the bole. Frequently, some roots of windthrown trees are not torn from the ground and remain functional for some time. This also can contribute to maintaining phloem quality, especially on the undersides of windthrown trees. As described in the Introduction, spruce beetles in windthrown trees are protected by snow cover during winter from extremely low temperatures as well as from predation by woodpeckers. All of these characteristics make spruce windthrow in general, and especially the bottom and sides, preferred habitat for spruce beetle. This preference apparently evolved even though the rates of brood development in shadier sides of windthrow are reduced, resulting in an extended life cycle in the preponderance of the brood in most years. Hence, it appears that the evolution of this preference is the result of a trade off between development rates and survival.

Based on studies of mountain pine beetle behaviour in relation to heat and light conditions, Shepherd (1965) hypothesized that both high heat and high light intensity stimulate flight. Therefore attacking beetles tend to seek the shadier aspects of the bole. This hypothesis is consistent with the nature of the circular distribution of spruce beetle attacks in windthrow, as well as published information cited earlier regarding the distribution of attacks by this species in trees and stumps, as well as attack and brood densities in windthrow.

The results presented here have implications for sampling spruce beetle populations in windthrow to determine population density, brood survival and the relative sizes of the attacking (parent) and emerging (offspring) population. These results indicate that reliable estimates of mean attack density may be obtained by taking samples along the sides of the bole. However, as the distribution around the bole of brood survival is affected by a number of factors in addition to attack density (including habitat quality, competition for food and space, and predation), the location around the bole of mean brood survival may be different from that of attack density and egg gallery length.

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SCIENTIFIC NOTE

Eleodes obscurus (Coleoptera: Tenebrionidae): confirmation of a Canadian population and possible northward expansion from Washington State into British Columbia in the Okanagan Valley

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Eleodes is a western North American tenebrionid beetle genus of about 130 species, 14 of which are recorded in British Columbia (Bousquet and Campbell 1991). Most are restricted to BC's Southern Interior grasslands, where they are a distinctive component of the insect fauna. The large size and the defensive habit of many species (headstanding and releasing irritating quinone compounds (Tschinkel 1975)) make them conspicuous. The genus is often the subject of ecological and population studies in grasslands and desert ecosystems (e.g., Crist *et al.* 1992).

Eleodes obscurus (Say) ranges from southern BC south to northern Mexico and east to Texas, Kansas and Wyoming, with most of the range west of the Rocky Mountains occupied by the subspecies *E. obscurus sulcipennis* Mannerheim (Charles. A. Triplehorn, pers comm.; Blaisdell 1909). Triplehorn (pers. comm.) gives the distribution of *E. obscurus sulcipennis* as Arizona, Nevada, Washington, Oregon, California, Idaho, Montana, and Texas in the United States and Sonora, Chihuahua, Coahuila, and Durango in Mexico.

In Canada, *E. obscurus* is recorded only from British Columbia (Bousquet and Campbell 1991). There are reports from the Okanagan in 1912 and 1913 (Brittain 1913, 1914); the only locality noted is Larkin in the North Okanagan (Brittain 1914). Apparently, these are the BC records cited by Boddy (1965), but it is not known if the identifications are accurate or if the specimens exist in any collection. No Canadian collections that we checked (Canadian National Collection of Insects, Ottawa; Pacific Forestry Centre, Victoria; Royal British Columbia Museum, Victoria; Spencer Entomological Museum, Vancouver) contain BC material collected earlier than our own specimens discussed herein. Charles Triplehorn (pers. comm.) has no Canadian records in his extensive data.

As part of a large study by Scudder (2000) on the biodiversity of terrestrial arthropods of the Antelope-brush steppe in the South Okanagan Valley, Latham (1995) reported on the distribution of tenebrionid beetles that Scudder collected in 1994 and 1995. Pitfall traps set at ten sites ranging from the east side of Osoyoos Lake, Oroville, WA, in the south (48°58'N 119°25'W) to the south end of Vaseux Lake, BC, in the north (49°16'N 119°30'W) collected nine species of tenebrionid beetles, including six of *Eleodes*. *Eleodes obscurus* was collected only at the Washington State site, which is about a kilometre south of the International Boundary and it was recorded in all months between May and September. The species has been common and widespread in eastern Washington for many years (Rogers *et al.* 1978).

Although we collected extensively around Osoyoos Lake in the 1970s and 1980s, we never found *E. obscurus*. Scudder did not collect a single specimen at the Haynes Ecological Reserve (north end of Osoyoos Lake), which he monitored by monthly pitfall trapping from 1991 to 2008. However, about 20 km to the southeast, near his home in Osoyoos, he ran traps in remnants of Antelope-brush steppe; ten specimens came from these collections (1992-

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1996). In addition, starting in 1990, he and his wife hand-collected specimens around their garden, recording 14 specimens up to 2008; ten of these were from 2004 and later.

All this suggests that although *E. obscurus* has been widespread in the dry grasslands of Washington State for decades, it has been absent or rare in the adjacent Okanagan Valley in Canada. A couple of historic records from 1912-13, when the species was reported as a possible agricultural pest, are unverified and possibly represent misidentifications, given that there are several large *Eleodes* species and other similar tenebrionids in the region. *Eleodes obscurus*, with its large size and striking defensive behaviour, is readily recorded when it is present. The notable increase in records since 1990 around Osoyoos, BC, immediately north of the International Boundary, indicates that the beetle's range may be expanding northward. Future records from grasslands to the north of Osoyoos Lake will confirm this observation.

Material examined. Collections housing material are abbreviated thus: CNCI (Canadian National Collection of Insects, Agriculture and Agrifood Canada, Ottawa, ON), GGES (G.G.E. Scudder Collection, Vancouver, BC), RBCM (Royal British Columbia Museum, Victoria, BC), UBC (Spencer Entomological Museum, University of British Columbia, Vancouver, BC)

CANADA: BRITISH COLUMBIA: Osoyoos, East Bench, 49°1'31.88"N x 119°25'12.43"W, *Purshia* association, pitfall trap, 20.iv.-11.vi.1992 (1), 11.vi-3.vii.1992 (3), 9.v-17.vi.1993 (1), 5.viii-12.ix.1994 (1), 8.v-13.vi.1996 (1), 13.vii-16.viii.1996 (2), G.G.E. Scudder (UBC); 13.vii-16.viii.1996 (1) G.G.E. Scudder (RBCM). Osoyoos, East Bench, 49°1'34.00"N x 119°25'15.00"W, hand collected in garden, 12.vi.1990(1), G.G.E. Scudder (UBC); 30.vi.1991 (1), 20.vi. 2001 (1), J. Scudder (UBC); 25.v.2002 (1) G.G.E. Scudder (UBC); 25.v.2002 (1), G.G.E. Scudder (UBC); 24.v.2004 (1), R.R. Stubbs (CNCI), 1.vii.2004 (2), 8.vii.2004 (1), G.G.E. Scudder (CNCI); 14.v.2005 (1), 27.v.2005 (1), 28.v.2005 (1), 27.vi.2005(1), G.G.E. Scudder (UBC); 27.v.2008 (1), J. Scudder (CNCI); 12.vi.2009 (1), 17.vi.2009 (1), G.G.E. Scudder (RBCM); SOCAP site 7 (H90-73) [unknown South Okanagan site], 9.v.1990, H. Knight (RBCM).

USA: WASHINGTON: Oroville, E Osoyoos Lake, 48°58'N x 119°25'W, *Purshia* association; AN, BGxh1, pitfall trap, all collected G.G.E. Scudder. 5.v-30.v.2004 (1, GGES; 4, UBC); 30.v.-5.vii.1994 (6, RBCM; 4, UBC); 5.vii.-2.viii.1994 (4, CNC; 3, UBC); 2.viii.-6.ix.2004 (11, UBC); 6.ix-6.x.1994 (2, UBC); 4.v.-7.vi.2005 (3, UBC);7.vi-9.vii.1995 (2, UBC); 7.vii-9viii.1995 (6, UBC).

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SCIENTIFIC NOTE

Notes on the taxonomy and status of the genus *Hesperia* (Lepidoptera: Hesperiidae) on Vancouver Island

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The genus *Hesperia* includes five species in British Columbia (BC), the most widely occurring of which are *Hesperia comma* (Linnaeus) and *Hesperia colorado* (Scudder) (Layberry *et al.* 1998). Although *H. comma* and *H. colorado* have sometimes been considered conspecific (Guppy and Shepard 2001), most recent authors recognize them as distinct species (Layberry *et al.* 1998, Pyle 2002, Acorn and Sheldon 2006). *H. comma* is presently considered to be a holarctic species found throughout the boreal forest in North America, extending into southern BC at higher elevations, with *H. colorado* occurring throughout the western United States and ranging north into southern BC (Guppy and Shepard 2001). In the northern part of its range, *H. colorado* generally occurs in dry grassland at low elevations (Layberry *et al.* 1998, Acorn and Sheldon 2006). Apart from differences in habitat, the two species may be distinguished by differences in size and in the colouration of the ventral hind wings.

On Vancouver Island (VI), *Hesperia* skippers live in two habitat types: dry meadows at low elevations on the southeast of the island and in natural meadows and disturbed areas in upper montane to alpine zones. There are few recent records from low elevations and few records at all from high elevations. *Hesperia* skippers on VI were once considered *H. comma manitoba* (Hardy 1954), but, more recently, they have been considered *H. colorado oregonia*, which is found west of the Cascade Mountains from VI south to northern California (Layberry *et al.* 1998, Guppy and Shepard 2001). Until now, the scarcity of specimens from the mountains of VI has prevented a comparison of the high and low elevation populations in series.

Between 2006 and 2008, a series of eight specimens (seven male, one female) of *Hesperia* skippers from subalpine habitats at five locations on VI was obtained by combining new collections made by the author with material borrowed from the research collection of Crispin Guppy. These were compared to the 24 male specimens from low elevations that are held in the entomological collection of the Royal British Columbia Museum in Victoria. Based on the colouration of the ventral hind wings, the mountain populations are clearly *Hesperia comma*. Compared to lowland specimens, mountain specimens have a darker base colour on the ventral hind wings, with medial markings that are white rather than light yellow (Figure 1). On the dorsal surface, the brown margins are wider and darker on mountain specimens and the apical spots within the margins are smaller. Mountain specimens are also consistently smaller. The average fore wing length is 12.5 mm (range 12.0 mm – 14.0 mm, n = 7) for male mountain specimens, compared to 14.5 mm for male lowland specimens (range 13.6 mm – 15.2 mm, n = 24. The high-elevation specimens are consistent in size and colouration, despite being collected from an altitudinal range of over 500 metres. Similarly, the morphology of the low elevation specimens is consistent; there are no trends in size or colouration along gradients of altitude or latitude.

Hesperia skippers on VI, therefore, represent two species, *H. colorado oregonia* at low elevations and *H. comma* (subspecies undetermined) at high elevations. *H. colorado oregonia* has been collected from at least 17 locations, but has been recently confirmed at only two of these (Table 1). It is believed to be extirpated from at least eight of the historic locations (Miskelly, unpublished data). It is associated with Garry oak (*Quercus garryana*) ecosystems, which have been reduced to less than five percent of their historic coverage and are declining rapidly due to urbanization (Fuchs 2001, Lea 2006). *Hesperia colorado oregonia* is apparently very rare in Canada. *Hesperia comma* is probably widespread in the mountains of VI, though more sampling is required to confirm its status and determine to which subspecies it belongs. Specimens examined appear similar to *H. comma manitoba* collected from interior and northern BC. No comparison has yet been made to specimens of *H. comma hulbirti* from the nearby Olympic Peninsula.

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Figure 1. Ventral view of six male *Hesperia* specimens from low elevations (top two rows) and high elevations (bottom two rows) on Vancouver Island, showing differences in size and patterning.

Table 1.
All known location records for *Hesperia colorado oregonia* in Canada, with current status as of 2009.

Location	Last Record	Status
Blenkinsop Lake	1951	Extirpated
Braefoot	1953	Extirpated
Camas Hill	2009	Extant
Cordova Spit	2008	Extant
Goldstream	1952	Unknown
Island View Beach	1963	Extirpated
Langford	1955	Unknown
Malahat	1923	Unknown
Maple Bay	1935	Unknown
Mt Douglas	1953	Extirpated
Mt Wells	1953	Unknown
Observatory Hill	1955	Unknown
Quamichan Lake	1917	Extirpated
Rithet's Bog	1961	Extirpated
Royal Oak	1956	Extirpated
S Wellington	1970	Unknown
Shawnigan Lake	1894	Unknown
Uplands Park	1953	Extirpated

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SCIENTIFIC NOTE

New record of *Eurytomocharis eragrostidis* species complex (Chalcidoidea: Eurytomidae) infesting teff (*Eragrostis tef*) in Oregon

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Teff, *Eragrostis tef* (Zucc.) Trotter (Poaceae: Eragrostoidae), an annual warm season grass, is a major cereal crop in Ethiopia and a hay crop in other African countries (Twidwell *et al.* 2002). It was introduced to the United States for production and use as grain or fodder (McDaniel and Boe 1990; Stallknecht *et al.* 1993). It is being raised as a seed crop in the Willamette Valley, which is a key agricultural area in Oregon, stretching from Portland to Eugene between the Cascade and Oregon Coast mountain ranges.

In August 2008, examination of a poor stand of teff in a seed production field in Linn County, OR (Site 1: 44.5447° N, 123.1100° W) led to the detection of several 1-2mm insect emergence holes at the base of the stems (Fig. 1). Here we report the identity of the insect that emerged from these and other damaged stems.

In addition to the stand at Site 1 listed above, a second field was examined (Site 2: 44.4486° N, 123.2067° W). Infested plants from both sites were transported to the laboratory and individual stems were isolated, examined for signs of infestation, cut and placed in 4-dram glass vials to await emergence of the adult insects. Photoperiod in the lab was 14 hours and temperature averaged 30 °C. Representative adults were preserved in alcohol and sent for identification to the Systematic Entomology Laboratory, United States Department of Agriculture – Agricultural Research Service, in Washington, DC.

Adults emerged over a 7-day period after enclosure in vials. In all, 21 males and 27 females were recovered from Site 1, and 5 males and 9 females were recovered from Site 2. The adults were identified by Dr. Michael Gates, USDA-ARS, as *Eurytomocharis eragrostidis* species complex (Hymenoptera: Eurytomidae). Species separations are currently difficult and characters used for identification are variable intraspecifically (Gates personal communication). Voucher specimens are deposited with Dr. Gates at the Systematic Entomology Laboratory.

Damage varied at the two sites. At Site 1, approximately 70% of randomly sampled plants were infested. However, this field was not irrigated adequately at planting and the stand was poor; the crop may have been unusually vulnerable to infestation due to extended water stress on the seedlings. At Site 2, 10% of randomly sampled plants showed evidence of the pest, but the stand appeared well established and healthy.

This is the first record of the *E. eragrostidis* species complex in Oregon and the first record of damage to teff by an insect pest in the state. Teff has been raised in the Willamette Valley in Oregon for seed production for about 10 years, and no insect pest has previously been observed feeding on the crop.

Eurytomacharis eragrostidis, the species, was reported as a pest of teff in South Dakota in 1988 by McDaniel and Boe (1990). In that study, larvae were found in 30% of infested stems in late July at two widely separated locations. The presence of the pest resulted in stunted plant growth and 75% reduction in forage yield (McDaniel and Boe 1990). In all, 19 adults were recovered. The pest was observed only once in 5

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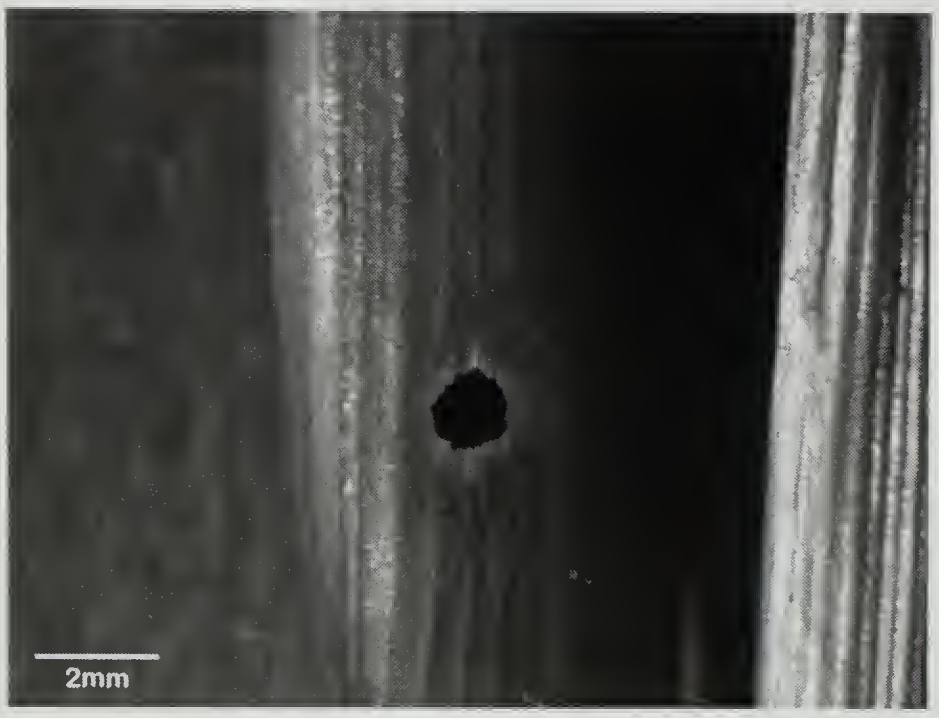

Figure 1. *Eurytomocharis eragrostidis* emergence hole at 10 cm from crown.

years of observation. In the Willamette Valley, the insect was detected because the grower was investigating the reason for a poor stand. It is possible that the wasp may be commonly present on teff and/or on an alternative host, perhaps controlled by natural enemies or causing damage below detection thresholds.

Teff has a niche market and several characteristics that make it attractive as a rotational crop for seed production in Oregon. Once established, it can be grown under a wide range of environmental conditions such as on marginal soils, water logged soils or under drought conditions (Stallknecht *et al.* 1993). It can produce a crop in a relatively short growing season and will produce grain for humans and fodder for cattle. Teff is low in gluten and is marketed in the US as a health food product and as late-planted emergency forage for livestock (Stallknecht *et al.* 1993). It appears to have low susceptibility to disease and pests when compared to other grain crops such as wheat (Stallknecht *et al.* 1993). However, its susceptibility to the *E. eragrostidis* species complex and damage that could lead to losses could be a deterrent to commercial expansion of this crop. Future monitoring of teff in Oregon is required to determine whether the *E. eragrostidis* species complex is an occasional pest, as it was in South Dakota in 1988 (Twidwell *et al.* 2002), or an ongoing problem in the Willamette Valley.

We thank the growers for drawing our attention to the damage in teff and allowing us to survey their fields, Michael Gates at the Systematic Entomology Laboratory for identification of the wasp, and Glenn Fisher for manuscript review.

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Abstracts

Entomological Society of British Columbia Annual General Meeting, Henry Grube Education Centre, Kamloops, BC, Oct. 2, 2009

Current insect pest issues in the interior of British Columbia

Susanna Acheampong. *BC Ministry of Agriculture and Lands, 200 – 1690 Powick Road, Kelowna, BC, V1X 7G5, Ph: (250) 861-7230, Email: Susanna.Acheampong@gov.bc.ca*

Insect pests of concern during 2009 on apples, cherries, grapes and forage crops will be discussed. Pest species include apple clearwing moth (*Synanthedon myopaeformis*), apple leaf curling midge (*Dasineura mali*), woolly apple aphid (*Eriosoma lanigerum*), Western grape rootworm (*Bromius obscurus*), grasshoppers, and an unidentified alfalfa caterpillar. Research needs will be highlighted.

Seasonality and the Latitudinal Gradient of Diversity: the BC Eocene Insect Perspective

S. Bruce Archibald. *Dept. of Biological Sciences, Simon Fraser University, 8888 University Drive, Burnaby, BC, V5A 1S6 Canada sba48@sfu.ca*

I tested the hypothesis that the latitudinal diversity gradient is a function of seasonality, not mean annual temperature, comparing insect diversities in cool, seasonal Massachusetts; hot, equable Costa Rica, and; cool, equable Eocene BC. BC Eocene insect diversity was high, implying that high tropical diversity is associated with seasonality.

Chasing Pollinators

B. Bains[1], Caldicott, A[1]. and Heron, J[2]. [1]*BC Conservation Foundation and* [2]*B.C. Ministry of Environment*

Pollination by insects is vital for the production of agricultural crops growing throughout British Columbia. A decline in the abundance and distribution of native pollinators and managed honey bee colonies appears to be worldwide. We used wandering transects to survey for target species at risk, such as the Western Bumble Bee (*Bombus occidentalis*), and other native pollinators on privately owned or privately managed lands. None of the target species were observed; however important land owner contacts were made for future sampling.

Expression of large lipids transfer proteins in *Helicoverpa zea*: differential regulation by juvenile hormone

Mustafa G. Cheema, Jason Kim and Norbert H. Haunerland. *Department of Biological Sciences, Simon Fraser University, Burnaby, BC V5A 1S6*

VHDL, a storage protein evolutionarily related to vitellogenin, is strongly expressed in last instar larvae when JH is absent. Treatment with JH analogs suppresses VHDL expression, while other vitellogenin gene family members are up-regulated. The results suggest that gene duplication and subsequent changes in the promoters gave rise to these proteins.

Mountain pine beetle condition and timing of emergence: who emerges when?

Alex Chubaty and Melanie Hart. *Department of Biological Sciences, Simon Fraser University, Burnaby, BC V5A 1S6*

Individual variation in energy reserves and timing of emergence are expected to constrain host selection decisions of mountain pine beetle. We examined the timing and condition of emerging beetles, describing the probability of emerging on a particular day with a particular condition, which can be used in models of individual host selection and attack.

Cranberry Tipworm, *Dasineura oxycoccana* (Diptera: Cecidomyiidae), and the

potential for host race formation in cranberry and blueberry fields

Melissa Cook. *Department of Biological Sciences, Simon Fraser University, Burnaby, BC V5A 1S6*

Cranberry Tipworm, *Dasineura oxycoccana* (Johnson) (Diptera: Cecidomyiidae), is a gall forming insect known to attack cranberry and blueberry fields in British Columbia. Cranberry tipworm has the potential for host race formation on these two crops. Here I present relevant results and some early conclusions from my first field season.

Pheromone-release behaviour of female cranberry tipworm, *Dasineura oxycoccana*, (Diptera: Cecidomyiidae)

Sheila M. Fitzpatrick and Daniel A.H. Peach. *Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, PO Box 1000, 6947 Highway 7, Agassiz, BC, Sheila.Fitzpatrick@agr.gc.ca*

Cranberry tipworm, *Dasineura oxycoccana*, is a pest of concern on cranberry, *Vaccinium macrocarpon*. If pheromone could be identified and synthesized, growers would have a tool for monitoring adult male tipworms. One- to three-day-old female tipworms showed pheromone-release behaviour predominantly during the first 6 or 7 hours of a 16-hour photophase. This would be the time to obtain pheromone for identification.

Invasive and new grape pests

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Grapes and other plants of the family *Vitaceae* are not native to the southern interior of British Columbia and no pests specific to grape were present here prior to the introduction of these plants. The dozen or so native pests that fed on grape, including a complex of climbing cutworm, were augmented by other polyphagous pests, such as the European red mite, *Panonychus ulmi*, introduced on shipments of potted plants prior to the 1900s. Later, importation of grapevines from Europe and eastern North America introduced a number of pests specific to grapes, such as grape phylloxera, *Daktulosphaira vitifoliae*, and grape erineum mite, *Colomerus vitis*. The rate of new introductions has increased recently due to rising world trade, increased travel, and rapid transportation of goods and people by air. Reflecting this change, the past two seasons have seen outbreaks of western grape rootworm, *Bromius obscurus*, in the Kelowna area and a widespread infestation of grape leaf rust mite, *Calepitrimerus vitis*, such that approximately 30 pests of grapevines now occur in BC. Although it is difficult to predict how damaging an introduced pest is likely to become, the greatest threat is posed by insects in the orders Lepidoptera, such as the grape berry moths, Coleoptera and Homoptera. At least eight species of non-native grape pests belonging to the latter group, including hard and soft scale, now occur in BC, and Homopteran pests are the largest group on most quarantine lists. Nine scale and mealybug species occur on grapes in Europe; a complex of six leafhopper species feed on grapes in eastern NA. In addition to invasive pests, more damaging biotypes or races can arise from existing pests and native species can adapt to feed on grapes. For example, the omnivorous leafroller, *Platynota stultana*, and the orange tortrix, *Argyrotaenia citrana*, became pests of grapes in NA during the 1960s. In light of the serious economic threat that new and invasive pests pose to the BC grape and wine industries, a comprehensive management program that includes changes in legislation, local production of clean nursery material, co-operation with the Canadian Food Inspection Agency, and a commitment to research is required to prevent new introductions and minimize potential damage.

Effect of residual Capture 2EC on wireworms

Selina McGinnis, Wim van Herk and Bob Vernon. *Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, PO Box 1000, 6947 Highway 7, Agassiz, BC*

Wireworms are still affected by the pyrethroid insecticide Capture 2EC (bifenthrin) one year after its application to soil in efficacy studies in the field. We present results from laboratory studies demonstrating how residual Capture 2EC affects wireworm mobility and health, and discuss some implications of this.

Fragments of the forest: Ground beetle diversity in Coquitlam, BC

Robert McGregor. *Institute of Urban Ecology, Douglas College, PO Box 2503, New Westminster, BC V3L 5B2*

Urban development inevitably fragments remnant natural habitat in cities. Clearly, fragmentation can affect community structure in resulting habitat fragments, but such effects have rarely been quantified in urban ecosystems. Previous work in Coquitlam, BC established that ground beetle communities (Coleoptera: Cararabidae) vary between disturbed areas and fragments of intact forest. In July and August of 2008, beetle communities were sampled in forest fragments in Coquitlam parks ranging in area from 4 to 180 hectares. Beetles were sampled in eight parks along 100 meter transects each with 5 pitfall traps arranged from the edge to the interior of the park. Measures of community structure and diversity were compared among sites differing in area and among trapping positions along transect lines. Results are discussed relative to the capacity of urban forests to maintain biological diversity and the effects of urbanization on biological communities.

The role of nitrogen fertilizer in a greenhouse biological control system

Chandra E. Moffat and David R. Gillespie. *Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, PO Box 1000, 6947 Highway 7, Agassiz, BC*

Bottom-up effects of nutrient availability on host-parasitoid population dynamics were investigated in a bell pepper-pest-parasitoid system. Aphids and parasitoids showed increased population growth rates and fitness as nitrogen availability increased, indicating the impacts of habitat fertility on tri-trophic interactions and suggesting implications for biological control.

Identification and biology of climbing cutworm (Lepidoptera: Noctuidae) from grapevines in the Okanagan Valley, B.C.

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Climbing cutworms are serious pest of grapes in the Okanagan Valley, British Columbia. Twenty species of climbing cutworm were collected as larvae from vineyards in south central BC during the spring of 2001 to 2008. *Abagrotis orbis* was the dominant species, and with *A. nefascia* and *A. reedi* accounted for over 85% of the reared moths. Life cycle aspects of *A. orbis* were assessed under three temperatures (11, 15 and 22 °C), two light regimes (16L:8D and 12L:12D photoperiod), and on two larval diets. Several observations suggested that occurrence of some crucifer plants in the vine rows decrease climbing cutworm infestations. Hence, feeding preferences and suitability of 13 host plants and post-dormant grape buds was also investigated for *A. orbis* in the lab.

Behavioral changes in parasitized aphids at episodic high-temperatures

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We investigated the effects of the severity and frequency of high-temperature events, on the survival and site of mummy formation of *Aphelinus abdominalis* Dalm. (Hymenoptera: Aphelinidae) attacking green peach aphids, *Myzus persicae* Sulz. (Hemiptera: Aphididae) on pepper, *Capsicum annuum* L. plants. Experimental conditions were four factorial combinations of magnitude and frequency of temperature extremes produced in plant growth chambers. All chambers were adjusted so that the average temperature over 24 hrs was always 23°C. The temperature extremes were 32°C in the low extreme (Le) and 40°C in

the high extreme (He). Plants and insects were exposed to these extreme events either daily (high frequency, Hf) or on day 2 and 5 in a 7 day cycle (low frequency, Lf). There was no effect of the different combinations of extreme temperature and frequency on the total number of mummies formed. However, more mummies of *A. abdominalis* were formed off the plant when exposed to high temperature peaks on a daily basis (HeHf and LeHf), than when exposed to high temperature peaks twice in a 7 day cycle (HeLf and LeLf). This response was greater when the extreme temperature peak was 40°C (HeHf) than when it was 32°C (LeHf). Our results suggest that increases in the frequency and severity of extreme temperature events, may trigger adaptive behaviours in parasitoids that will facilitate their survival during such events. Such shifts in behaviour could change the frequency and severity of pest outbreaks.

Butterfly Surveys in Southeastern BC: some observations, comments and future work

Laura Parkinson, Sophie-Anne Blanchette and Jennifer Heron. *B.C. Ministry of Environment*

Although insects and other invertebrates represent a majority of the biodiversity in British Columbia, there have been relatively few surveys conducted across the province to inventory these groups and assess the conservation status of individual members. In response to a growing need to expand the body of knowledge on the status of rare invertebrates in B.C., a two person crew conducted surveys between June 16th and August 5th 2009 in three areas in southeast coastal BC for rare butterflies and opportunistically for other rare invertebrates. Surveys were conducted on foot along roads adjacent to suitable habitat for each target species and within the habitat itself, if possible. Butterflies were identified in flight wherever possible or caught in nets and subsequently released if identification required closer inspection. From June 16th to June 24th surveys were conducted in the Sechelt area of Sunshine Coast, primarily targeting Johnson's hairstreak. Surveys were conducted in the Harrison Lake area between July 3rd and July 22nd primarily targeting Dun Skipper. Finally surveys were conducted for Bremner's Fritillary between July 28 and August 5 on Salt Spring, Mayne and Galiano Islands. A combined survey effort of 197 hours was spent surveying 264 km at 52 different sites. At least 20 different species of butterflies were observed (this is likely an underestimate as some individuals could not be identified to species), including three red listed species and two introduced species. Red listed species observed included a Johnson's hairstreak in Sechelt and at least 17 Bremner's fritillaries observed on Salt Spring Island, as well as a common wood nymph opportunistically observed on Salt Spring Island. No dun skippers were observed during any of the surveys and no red listed species were observed in the Harrison Lake area.

Hymenopteran parasitoids from cranberry tipworm, *Dasineura oxycoccana*, collected from a cranberry farm in BC

Daniel A. H. Peach and Sheila M. Fitzpatrick. *Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, PO Box 1000, 6947 Highway 7, Agassiz, BC, Sheila.Fitzpatrick@agr.gc.ca*

We report the first instance of parasitoids emerging from cranberry tipworm, *Dasineura oxycoccana* (Johnson) (Diptera: Cecidomyiidae), collected from cranberry, *Vaccinium macrocarpon* Ait., in British Columbia in 2009. The parasitoids are Eulophidae and Platygastridae, with the eulophid accounting for 78.3% of emerged parasitoids. If conserved, these parasitoids could contribute to biological control of cranberry tipworm in BC.

Chemical cues mediating clonal preference of *Leptoglossus occidentalis* in a lodgepole pine seed orchard

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Multiple surveys were conducted in a lodgepole pine seed orchard in British Columbia in 2008, revealing that *Leptoglossus occidentalis* (Heidemann) prefers certain clones to others. We tested the hypothesis that clone preference is based on chemical cues from host trees, sampling monoterpenes from cones of favoured and unfavoured clones. Analysis of variance and post hoc means separation tests revealed different quantities of semiochemicals in the cones of favoured and unfavoured clones. Contrary to previous studies, we also found that *L. occidentalis* favoured the same clones, and often the same trees, in consecutive years.

What makes an ideal biological control community?

Michael J. Wogin, Bernard D. Roitberg and David R. Gillespie. *Department of Biological Sciences, Simon Fraser University, Burnaby, BC V5A 1S6*

Due to the complex interactions that can occur among parasitoids sharing a common host, introducing a competitor into a system can have unpredictable results. We conducted field experiments examining the outcomes of intra-guild competition. Results, ecological implications, and ideal biological control communities are discussed.

Infrared radiation and its exploitation by coniferophagus insects

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In seed orchards, we show foraging response to infrared radiation (IR) by moths (*Dioryctria pseudotsugella*), midges (*Contarnia oregonensis*), and true bugs (*Leptoglossus occidentalis*). The latter may prefer IR in combination with visible light over IR alone, and possibly use IR also to locate mates, avoid predators, and seek overwintering sites.

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